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INDIVIDUAL DIFFERENCES IN HUMAN BLOOD[1]

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BECAUSE of the difficulties in working with substances of high molecular weight, one is as yet far from the goal of chemically characterizing the single proteins and determining the constitution of these substances, which rank as the most important components of living matter. Hence it was not the use of the ordinary chemical methods, but the application of serological reagents, which led to an important general discovery in protein chemistry, namely that the proteins in various animals and plants are different and are specific for each species. The multiformity is increased by the fact that also various organs contain particular proteins. It thus would appear that in the case of living organisms, special structural substances are required for each single form and function, in contrast to artificial machines, which, serving the most diverse purposes, may be constructed from a limited number of materials.

The discovery of biochemical species specificity prompted the question which formed the basis of the investigations about to be discussed, as to whether the specific differentiation goes beyond the limits of species, and whether also the individuals within a species show similar, though presumably slighter, differences. As no observations whatever were available pointing to such behavior, I chose the simplest amongst the possible plans of investigation, and that material which gave promise of useful application. Accordingly, the investigation consisted of allowing blood serum and red blood corpuscles of different human individuals to interact.

The results were only partially those that had been expected. In many tests, just as if the blood cells had been mixed with their own serum, no changes were

[1] Nobel Lecture read in German at Stockholm, December 11, 1930.

observed. Frequently, however, a phenomenon described as agglutination occurred, the serum causing a clumping of the cells of the other individual.

The unexpected feature was that the agglutination, when it did occur, was as marked as the well-known reactions in which serum and cells of different animal species interact, whereas in other cases there seemed to be no difference in the blood of various individuals. At this point it was still to be considered that the phenomena observed did not signify the individual differences sought for and that the reactions, though obtained with the blood of healthy individuals, might have been due to a past history of disease. It soon became evident, however, that the reactions followed a law which holds for the blood of all human beings, and that the properties observed are as characteristic for single individuals as are the serological properties distinguishing species. There are in the main four different kinds of human blood, constituting the so-called blood groups. The number of the groups depends on the existence in the erythrocytes of substances (isoagglutinogens) having two different structures, either or both of which may be present or absent in the erythrocytes of a given person. This alone would not be sufficient to explain the reactions; the active substances of sera, the isoagglutinins, must also occur in a definite distribution. Such is indeed the case, for every serum contains those agglutinins which act upon the agglutinogens not present in the cells, a remarkable phenomenon, the cause of which has not yet been definitely established. From these facts there follow definite relationships, shown in the table below, between the various blood groups, which make the task of their determination a simple one. The groups are designated according to the agglutinogens contained in the cells. (In the table the sign + indicates agglutination.)

Serum of group	Agglutinins in serum	Erythrocytes of group			
		O	A	B	AB
O	$\alpha\beta$	−	+	+	+
A	β	−	−	+	+
B	α	−	+	−	+
AB	−	−	−	−	−

The question will now be asked whether isoagglutination is limited to human blood, or occurs also in that of animals. As a matter of fact, such reactions are found among animals, but they are definite only in the case of certain species, and are hardly ever as consistent as in the case of man. Only the highest anthropoid apes—the blood cells of which are indeed distinguishable from those of man, the proteins as yet not definitely so—have blood group characteristics which, as far as has been investigated, are shown to coincide completely with those of man. It may be assumed that the comparative study of numerous animal species will serve to elucidate the phenomenon of group formation, which is not yet completely understood.

A noteworthy piece of work with respect to animal blood is already at hand. Very soon after the first observations on isoagglutination had been made, Ehrlich and Morgenroth described experiments in which they demonstrated variations in the blood of goats by the use of hemolytic antibodies—the isolysins—which were formed when the animals received injections of blood from other individuals of the same species. No typical blood groups were observed, but rather numerous apparently irregular differences, a finding which, apart perhaps from the intensity of the reactions, is about what might have been expected on *a priori* grounds. Similar investigations, particularly those of Todd on cattle and fowl,[2] pointed to almost complete individual specificity.

The apparent discrepancy between the observations made on man and the lower animals has recently been explained. Some suggestive observations having been reported previously, I was able, with Levine, to obtain definite results with the aid of special immune sera produced by injecting rabbits with human blood. This work led to the detection of three new agglutinable factors present in all four blood groups. Thus it could be established that there are at least 36 different types of human blood, if one also takes into account the subdivision of groups A and AB each into two subgroups,[3] which has been studied recently in my laboratory and thoroughly investigated by Thomsen. Furthermore, it could be demonstrated that iso-reactions of lesser intensity,[4] which do not follow the group rule and vary in their specificity, are more frequently found than was formerly supposed. As these irregular reactions can without difficulty be distinguished from the typical ones, they do not in the least invalidate the rule of the four blood groups. On the basis of these results we may assert that in the case of man there are numerous individual blood differences already demonstrated, and undoubtedly there exist still others which have not yet been established. Whether actually each individual blood possesses a special quality, or how frequently there is complete correspondence with the blood of others, can not be definitely stated at present.

These findings have, at the present time at least,

[2] Landsteiner and Miller, Todd.

[3] S. v. Dungern and Hirschfeld, Guthrie and collaborators.

[4] Unger, Guthrie and collaborators; Jones and Glynn; Landsteiner and Levine.

no special significance in the therapeutic application of the blood groups; they are, however, probably related closely to an important field of surgery, namely, that of the transplantation of tissues.

It has long been known that transplantation—for instance, of the skin—is much more successful when the transplanted tissue is that of the same individual, and this is also true of tumors transplanted to various strains of a species, as first described by Jensen. The experience of surgeons is confirmed by animal experiments, among which the important series of L. Loeb is especially noteworthy. His experiments consisted of the transplantation of different tissues—from the same individual, from those having blood relationship, from those not so related or belonging to different varieties and species. In general the success of transplantation stood in a reciprocal relation to the degree of consanguinity, and a review of all the findings permitted the conclusion that the tissues of a single individual must possess special biochemical properties.

The agreement between the results of the two independent methods is so striking that one is immediately led to assume that there are differences of substantially the same kind which, on the one hand, determine the individual variations detectable by means of serum reactions, and on the other, the individually specific behavior of transplants. As a support for the assumption it may be cited that the group characteristics, besides being present in the blood, can also be demonstrated in the cells of organs. On the basis of this theory, *i.e.*, taking into account the blood groups, it has been attempted to make tissue transplantation more successful; such efforts, however, have not led to consistent results. But this is understandable, for the blood groups constitute only a part of the existing serological differences, and even apparently slight deviations may influence the take of the transplant. Consequently, the difficulty that arises from the experiments may seem to be disposed of, and the most probable supposition would be that the two series of phenomena—the serological differences of the individuals and the transplantation specificity—are related in nature and depend on chemical differences of a similar sort. Hence there still remains a possibility that serum reactions may be employed in the future for the important problem of transplantation, although the knowledge available at present justifies no more than a hope in this direction.

Turning now to the question of the chemical nature of the substances underlying individual specificity, the answer, although almost wholly in the negative, is not without interest. The above-mentioned precipitin reactions, which revealed the species differences of proteins, were so impressive that the belief arose that proteins or related substances form the substrate of all serological reactions. This view was first disturbed by studies made on blood antigens. The solubility of specific substances in organic solvents, and particularly the investigations of the heterophile antigens of sheep blood, and organs of diverse animals discovered by the Swedish pathologist Forssman, which on extraction with alcohol yield a substance that is specifically binding but does not act as antigen, led me to the opinion that those parts of many cell antigens which determine their specificity are not albuminous substances, and that these fractions do not become antigenic until they are combined with proteins to form what may be conveniently called "complex antigens." A strong support for this view was found in the fact that it was possible by admixture with albuminous solutions to restore the antigenic power of the specific substance.[5]

Analogous results were obtained from the study of certain specific substances contained in bacteria (Zinsser). While for bacteria the chemical nature of the specific binding substances, or haptens, could be established with certainty—one deals in this case with colloidal polysaccharides (Avery and Heidelberger)—we do not yet possess definite information on the animal cell antigens. Nevertheless it may be stated that the biochemical characteristics of animal species are based on the existence of two diverse classes of species specific substances[6] which exhibit essential differences in the manner of their appearance.

What directly concerns our subject is the fact that group specific substances may also be extracted by alcohol from the blood corpuscles, and in general permit the formation of antibodies in this state only when mixed with antigenic proteins. We may, therefore, conclude that the haptens vary within a species, while analogous serological differences of proteins, although suspected, can not be definitely asserted. Another peculiarity is the fact that haptens which show relationships according to their reactions frequently are encountered in animal species widely separated in the zoological system. Thus isoagglutinogen A is serologically related to Forssman's antigen present in sheep blood, and for that reason certain immune sera react with sheep blood and with human blood of groups A and AB, but not with blood of groups O and B (Schiff and Adelsberger). Even more remarkable is the occurrence of similar structures in bacteria, which is shown by the presence of sheep lysins and apparently anti-A agglutinins in some antibacterial sera. This seems to be the case with

[5] Landsteiner and Simms.

[6] Landsteiner and Van der Scheer, Bordet and Renaux.

some anti-paratyphoid B immune sera, and a dysentery serum, recently described by Eisler, agglutinates human blood, and contains antibodies acting to a higher degree upon that one of the two subgroups of group A, which is less sensitive to the isoagglutinins.

The occurrence of isoantibodies showing individual differences is probably attributable, according to the results of investigations made on artificial complex antigens, to the fact that, through combination with other substances, proteins derived from the immunized species are capable of stimulating the formation of antibodies. If, on the other hand, haptens identical or closely related to those of the animal are injected in combination with foreign proteins, as a rule no antibodies are formed. As an example may be cited the experiments made by Witebsky, which demonstrated that group specific immune sera are formed after the injection of blood A only in the case of such rabbits whose organs do not contain substances similar to agglutinogen A. But that no definite rule can be set down is demonstrated by the experiments of Sachs and Klopstock on the appearance of the Wassermann reaction in rabbits after the injection of foreign serum mixed with alcoholic extracts of rabbit organs.

While in this instance the antibodies react only with organ extracts, O. Fischer, by injecting rabbit blood extracts mixed with foreign serum into rabbits, succeeded in producing autoantibodies which acted upon intact blood cells, and which were active hemolytically only after cooling, in a manner similar to the hemolysins which I, in collaboration with Donath, found to be the cause of hemolysis in paroxysmal hemoglobinuria. These results and the diversity of the immune sera produced with extracts of O and B red blood cells, and on the other hand with intact cells, point to the conclusion that the form of union of the substances within the cells also exerts an influence upon the antigen characteristics.

Following these brief remarks on individual blood differences and peculiarities of the cell antigens, we turn now to a discussion of the application of the group reactions. A voluminous literature, almost impossible of complete review, treating of the relative frequency of the individual blood groups among the various races of man, has come into existence since L. and H. Hirszfeld made the remarkable observation that in this respect there exist characteristic differences among the various races. Their most important finding was that the characteristic A is more frequently found among North Europeans than is the characteristic B, whereas the conditions are reversed among a number of Asiatic races. Another striking example is that the American Indians, when they are of pure race, belong almost exclusively to group O,[7] from which it is concluded that the occasional appearance of factors A and B is attributable to racial mixture.

To discuss the results of the anthropological investigations made on blood groups, and the conclusions derived therefrom, is beyond my province; the viewpoints of the various authors concerning the general principles and the individual problems are not in general accord. But there seems to be a prevailing belief that the behavior of the blood groups, in conjunction with other anthropological factors, may serve as an indicator of blood relationship and the descent of the races of man, and has, therefore, some anthropological significance.

A practical use of the group characteristics offered itself immediately for application in the differentiation of human blood stains for forensic purposes. With the aid of the precipitin reactions[8] it is not difficult to determine whether a certain blood stain is of human or of animal origin; but it was impossible for the forensic physicians to distinguish blood stains from various individuals. Since the isoagglutinins and the corresponding agglutinogens are preserved for some time in a dried state, the problem may be solved in certain cases, when the bloods to be examined—for instance, that of the accused person and that of the victim—belong to different blood groups. The occasions for employing the method are naturally not very frequent, and particularly in your country there is fortunately small opportunity for its use in this connection; but according to a report by Lattes, who was the first to apply the method in forensic practice, it has proved useful in a number of cases and has served as the basis for legal decision, sometimes as a criterion for establishing the innocence of the accused.

The group reactions have been employed far more extensively in forensic medicine in cases of disputed paternity. The possibility of making such decisions rests on the studies of the inheritance of the blood groups. The most important findings along this line we owe to v. Dungern and Hirschfeld. In their investigation they were able to determine that the two agglutinogens A and B are hereditary dominant properties, the inheritance of which follows the Mendelian law. The significance of this discovery lies in the fact that in the case of man there is hardly another physiological characteristic which can be so unequivocally demonstrated, and which at the same time follows so simple a rule. The genetic hypothesis of two independent pairs of genes, proposed by the above authors, had to be abandoned as the result of

7 Coca, Snyder.

8 Kraus, Bordet, Uhlenhuth.

the statistical work of Bernstein. On the basis of a definite gene hypothesis and on the premise of an adequate mixing of a certain population, it is possible to make calculations on the frequency of the inherited characters. A calculation of this kind was made by Bernstein, who found that the observed numbers and those calculated according to the hypothesis proposed by v. Dungern and Hirschfeld were widely divergent. On the other hand, there was complete agreement when the calculations were based on a hypothesis which postulates three allelomorphic genes in a certain locus of a chromosome. The assumption leads to definite expectations with respect to the children of AB parents, and these have been satisfied by the investigations of Thomsen, Schiff, Snyder, Furuhata and Wiener, with the exception of rare instances, which may possibly still be reconciled with Bernstein's theory. Hence the new theory has been almost universally accepted.

In forensic application, the dominance rule of factors A and B is standard. Hence paternity is excluded in all such cases in which a child is shown to possess A or B, when these characteristics are absent in the case of the mother and in that of the putative father. The test is quite frequently employed in several countries, particularly in Germany and Austria, and also in Scandinavia. In a review made last year by Schiff, he reports on about 5,000 forensic investigations, with 8 per cent. of excluded paternity, while according to a calculation there would be the possibility of such exclusions in 15 per cent. of the cases. In favor of the method it may be stated that it has also contributed to the recognition of illegitimate children by their fathers.

It may be of interest to indicate a further possible development in the decision of paternity. The preliminary results[9] obtained with two of the abovementioned blood properties demonstrated by immune sera point to the probability that their appearance is conditioned by a pair of genes, neither of which is dominant over the other, so that when both are present there results a mixed type. The existence of three phenotypes, M + N –, M – N +, and M + N +, is explained in that the last corresponds to the heterozygous, and the first two to the homozygous forms. Accordingly, the heterozygous form can be recognized directly. The implications of the hypothesis are shown in the next table.

Marriages	Progeny to be expected		
	M + N +	M + N –	M – N +
M + N + x M + N +	50	25	25
M + N + x M – N +	50	0	50
M + N + x M + N –	50	50	0
M + N – x M – N +	100	0	0
M + N – x M + N –	0	100	0
M – N + x M – N +	0	0	100

According to our observations, there were some exceptions to this rule, which prevented our final acceptance of the hypothesis. It is possible, however, that these exceptions are to be attributed to illegitimacy or to imperfections of the method of investigation, which is not as simple as that of the group determination; recently Schiff in his published observations on inheritance and population statistics was able to show complete agreement with the theory. Almost equally satisfactory are the recent unpublished results of Wiener.

If on further investigation the hypothesis should prove to be correct, the possibility of excluded paternity would be almost doubled, and a determination might be feasible in about a third of all cases. On the basis of the present data, it is, however, possible already to make statements having a considerable degree of probability. Further development may result from the inclusion of the subgroups of groups A and AB (Landsteiner and Levine, Thomsen), if additional observations confirm the supposed regularities.

The blood group reactions are more significant for practical medicine, in the case of transfusion. It would take us too far afield to enter more deeply into the history of transfusion, a history going back hundreds of years, to the time of the discovery of the blood circulation by Harvey. The possibilities of the operation were conceived even before that time, but, stimulated by Harvey's great discovery, it was first successfully carried out by Lower on dogs in the year 1666 in England, and during the following year the first transfusions of blood from animals to man were made by Denys in France, and Lower and King in England. Further efforts were directed toward the invention of special apparatus, and it was learned that it is not necessary to transfer the blood from vessel to vessel, but that also defibrinated blood may be used (Bischoff 1835). The first transfusion with human blood was probably made by Blundell during the first half of the 19th century.

How differently the operation was regarded may be illustrated by two points of view, cited by Snyder. In a "History of the Royal Society" (1607), Sprat stated: "Hence arose many new experiments, and chiefly that of transfusing blood—that will probably end in extraordinary success." Again, in a "History of the Royal Society" by Thompson (1812) it is stated: "The expected advantages resulting from this practice have long been known to be visionary." Not-

[9] Landsteiner and Levine.

withstanding all the efforts made, and the lively discussion of the problem, it was not possible to incorporate the procedure into medical practice, and the thought of its use had finally to be abandoned because the operation, while proving very useful in some cases, in others resulted in symptoms severe in character and even in death.

So far as the injection of animal blood was concerned, an explanation of the accidents was given by Landois, who as far back as 1875 discovered the phenomena of agglutination and hemolysis, which frequently took place when human blood was brought into contact with serum obtained from a foreign species. But it remained a mystery why the introduction of human blood into the circulation of man was at times dangerous, as it was considered a matter of course that the serum or plasma of the same species represents an innocuous medium, an assumption which was probably strengthened by the use of such sera in histological investigations.

The simple solution of the problem came in the discovery of individual blood differences and of the blood groups. Animal experiments, and particularly clinical experiences in cases where errors had been made in the determination of the blood groups, are confirmatory and leave no room for doubt that the transfusion of agglutinable human blood is, as a rule, accompanied by untoward consequences. The pathogenesis of shock following transfusion has, however, not yet been fully explained.

The first blood transfusion made on the basis of the agglutinin reaction was that of Ottenberg, but it was not until there arose the great need created by the world war that the method of transfusion from serologically selected donors was employed on a large scale and became definitely established.

It is not possible here to enter into details, such as the sources of error possible in the group determinations, their control through direct comparison of the recipient's with the donor's blood, and the precautionary rule of beginning the operation by the injection of small quantities of blood. It may, however, be mentioned that it is not absolutely necessary to employ blood of the same group, for we may also use other blood, for instance that of group O (see Ottenberg)—the cells of which are not influenced by the serum of any recipient. In the latter instance, however, it is necessary as a measure of safety to exclude donors with a high titre of agglutinins in their serum, as these may prove dangerous especially for severely anemic or weakened patients. The employment of the so-called "universal donors" of group O, or in general the use of inagglutinable blood of another group, may in an emergency and in the case of recipients belonging to the rare blood groups, be of great value.

Of the conditions indicating the employment of blood transfusion, the most important are acute and chronic anemia, that resulting from wounds, lung hemorrhages, in obstetrical practice, from tumors of the stomach and the intestines. The life-saving effect often produced in the case of hemorrhages is in the first instance of course attributable to blood replacement, and it is to be noted in this respect that the introduced erythrocytes may retain their function in the circulating blood over a period of weeks. Of significance also are the stanching of blood by raising the coagulability and probably the stimulation of blood regeneration in the bone marrow, as shown by changes produced in the histological blood picture. The great use made of blood transfusion in pernicious anemia has now become largely unnecessary through the discovery of liver therapy.

Another extensive field of application is in shock following severe injuries and operations. It is thought that in these cases the introduction of blood has a better effect than the injection of isotonic solutions, such as the common salt solution containing gums, employed by Bayliss during the war. According to these indications, apart from the blood replacement, transfusion can be employed with good results as a stimulant following major operations; in the case of weakened patients, American surgeons recommend its use even before severe operations.

Good results have also been obtained in haemophilia, thrombopenic purpura, and to a certain extent in agranulocytosis, CO poisoning, burns, while in a number of other diseases, for instance, the septicemias, in which transfusion was tried, the results have been uncertain.

Some figures which I presented before the International Microbiological Congress in Paris indicated the frequency of the use of transfusion therapy and the degree of comparative safety that has been achieved in this procedure, a result which in part at least is attributable to the considerable advances made in surgical technique. These statistics are not in entire agreement, as some authors, in contrast to others, still report occasional accidents. As these differences are probably ascribable to the technique employed in the procedure, I feel justified in basing judgment on the favorable reports provided they include a large number of cases.

The frequency of the operation is surprisingly great, and possibly it has at times been employed too extensively. According to statistics for which I am indebted to Dr. Corwin, of the New York Academy of Medicine, during the year 1929 there were about 10,000 blood transfusions given in New York City. In a recent publication of Tiber from Bellevue Hos-

pital in New York there are reported up to July, 1929, more than 1,467 transfusions made there in three and a half years. Among these transfusions, there were two deaths, one resulting from an error made in determining the blood group, and the other, also possibly avoidable, in an emaciated infant belonging to group A which received blood from a so-called "universal donor" of group O. Three deaths out of 1,036 transfusions reported by Pemberton, of the Mayo Clinic, were the result of errors in the determination of the blood groups. In Kiel, as I was informed by Dr. Beck, in the course of five years there were 2,300 transfusions given without a single death. In from 2 to 3 per cent. of the patients there were symptoms such as chills and a rise in temperature, which were, however, not of a severe character. A case of Beck's, one of pernicious anemia, is noteworthy: during a period of three and a half years, the patient received a total of 87 transfusions without any serious consequences.

Notwithstanding the favorable aspect of these results, there are reported, as said above, in addition to slight disturbances, exceptional severe and even fatal accidents which may not be attributable to errors in technique. It is not probable that in these cases the blood differences as indicated by the atypical isoagglutinins play an important rôle, in which event such accidents might easily be avoided. Whether, as has been assumed, injury can be caused by a marked pseudo-agglutination by the recipient's serum has not been definitely ascertained. Some of the disturbances appear to be due to allergy to food substances present in the injected blood, while others were ascribed to the action of antibodies formed as the result of former transfusions. The problem as to whether or not there are individual differences in protein which give rise to antibody formation has not been sufficiently investigated.

On the whole, the results obtained up to the present time with transfusion therapy are very satisfactory, and we may hope that an intensive study of the cases showing an unfavorable outcome will help to assess the significance of the supposed causes and reveal perhaps unknown ones, so that the slight degree of danger still attending the use of transfusions may be almost entirely averted.

Apart from the solution of this practical problem there is the possibility of developments resulting from the study of the biological aspects of individual serological differences in general, and particularly from the elaboration of procedures for finer differentiation of human blood and a continuation of the genetic analysis of serological blood differences in man and animals considering, that as a result of similar studies, we very probably possess to-day, apart from the sex chromosomes, knowledge of at least two pairs of human chromosomes which are marked by distinct characteristics.[10]

OBITUARY

JOHN HENRY COMSTOCK

Born in Janesville, Wisconsin, on February 24th, 1849. Died at his home in Ithaca, N. Y., March 20th, 1931. Between these dates, the career of one who rose from poverty and pioneer hardship to world service and honor.

His father was a frontier teacher, who died when the lad was three years old, and left him and his mother to struggle with want. At sixteen he became a sailor on the Great Lakes. Once in the course of his sailing when at anchor in the port of Buffalo, he visited a bookstore and came upon a copy of Harris's "Insects Injurious to Vegetation." Here was something that interested him beyond anything he had ever read. The illustrations fascinated him; but the price was beyond his means. He went sadly away. But he could not forego the possession of this precious book. He borrowed the money and returned and bought it; and this book had a large part in determining his future career.

At the age of twenty, though largely self-educated he was ready for college, and he entered Cornell University. That was in 1869, its opening year. He chose Cornell because there he could work his way; also, it was to be a place where in the words of its founder, one could "find instruction in any subject." So he came to study entomology.

But there was then no entomology at Cornell. There was, however, a sympathetic teacher of zoology, Dr. Burt G. Wilder, who promised the young man that he might work with insects to his heart's content. Under such friendly guidance his real work in entomology began.

So well did he work that he soon had a reputation for expert knowledge of insects; and so contagious was his enthusiasm that in the spring of 1872—his junior year—thirteen of his college mates petitioned the faculty to permit him to give them a course in entomology.

The request was granted. His teaching of entomology at Cornell began in a little room away up in the square tower of McGraw Hall, a building that had been built in part by the labor of his own hands. Later a department was created for him and in White

[10] While in press, an article on the subject was published by F. Bernstein, *Zeitschr. f. ind. Abst. u. Vererbungslehre*, 57: 113, 1931.

Hall for more than a score of years he was training men from all over the world for service in entomology.

His combined research-room and office was adjacent to his advanced students' laboratory, and the door between was generally open. Nothing in either was too sacred for use in the other if needed. He loved to share with his pupils the joys of discovery, and they delighted to share in his enthusiasm. There was no pretense about him, no derogation of the work of others, no bickering with those in whose beliefs he could not concur. His methods were those of simplicity and directness and reverence for truth. One of his admonitions that is perhaps best remembered by those who did research work under his guidance was this: "Be sure you are right, and then look again."

In the year 1872 he studied under Dr. H. A. Hagen during the summer vacation at Harvard. In 1878 he married Anna Botsford. The year 1888–9 they spent together at the University of Leipzig. In 1879 he became for a few years entomologist for the federal government at Washington. He then returned to Cornell where he taught continuously until his retirement in 1914.

Meanwhile, he occupied his winters from 1891 to 1900 with the work of organizing the department of entomology at Stanford University, teaching at Cornell during the summer by mutual agreement between the two universities. And, as he had sent L. O. Howard ahead of him to Washington and left him there to continue in the service, so he took V. L. Kellogg with him to Stanford and left him there to carry on.

After his retirement came a dozen fruitful years, during which he rounded out his life as a productive scholar. He had previously published his "Manual for the Study of Insects," and had repeatedly revised it for many editions, and had made it the most generally serviceable entomological text-book of his generation. He had published also "How to Know the Butterflies" and "Spider Book." Now, when freed from classroom duties and office routine, he settled himself to put together in final form the ripe results of his chief entomological studies. First appeared "The Wings of Insects," and later "An Introduction to Entomology." His books were products of slow and steady growth, and they are his chief monument.

In his later years he was the recipient of many honors. His pupils established at Cornell University a Memorial Library of Entomology to bear his name. The Fourth International Entomological Congress made him an honorary member. He was an honorary member of the Entomological Society of London. He was a member of the Entomological Society of France and of the California Academy of Sciences. A number of American national societies—entomologists, naturalists, zoologists—claimed him a member, fellow and betimes president.

In his day he taught entomology to more than 5,000 students. Practically all of these at some time or other entered the hospitable Comstock home. All the entomological world knows how John Henry and Anna Botsford Comstock worked together for more than half a century; how they supplemented and aided each other; how common were their interests; and how mutual was their labor. All know, also, how generous was their hospitality. Many savants from foreign shores were their guests. Many struggling students found under their roof-tree a second home.

Mrs. Comstock preceded her husband into the Great Unknown by half a year. Their ashes rest in a grave under an oak tree on a knoll in Lake View Cemetery at Ithaca. Within the view are the towers of the university of which they were so large a part. Outspread beneath lies Cayuga Lake and the valley they loved, with its flat woods and winding water-paths that they explored together in the days of their youth. Round about are the rugged hills of Ithaca whose insect fauna they made known to the world through intimate records and beautiful illustrations.

Their influence lives on in the hearts of thousands. One of Professor Comstock's earlier pupils, Dr. Ephraim Porter Felt, well expressed what they all feel when on March 21 he wrote:

> A great teacher has passed and left an enviable record. Professor Comstock endeared himself in a most charming way to all of his students. He exercised a very profound influence in establishing teaching standards for entomology. His writings are admirable models for his successors. His life was an inspiration to all searchers for truth, and an exemplification of possibilities in this land of equal opportunity.

JAMES G. NEEDHAM

MEMORIALS

THE John Burroughs Memorial Association made April 4 the occasion for the annual meeting of the association this year and a birthday celebration in the auditorium of the American Museum of Natural History. The speakers were Professor Franklin D. Elmer, of West Hartford, Conn., and Dr. Clyde Fisher, curator of visual education and astronomy of the museum. The object of the association is the acquisition and preservation of Slabsides, the house of John Burroughs, and the fostering of his teachings as a naturalist.

AT Bordighera, where Pasteur lived for several months, special ceremonies were held recently in his honor. The commemoration was attended by many Italian physicians, Frenchmen, Belgians, Americans and Jugoslavs, under the chairmanship of Professor

Forgue, of the University of Montpellier. Professor Nicola Pende, medical clinician of the University of Genoa, delivered the official address.

AN International Fund is to be raised for the erection of a monument in Rome to Carlo Forlanini, who introduced the artificial pneumothorax treatment for pulmonary tuberculosis.

THE *Journal* of the American Medical Association states that a medallion portrait and a tablet of steel have been affixed in the pavilion of the Hôpital Cochin, Paris, where Fournier devoted twenty years to research on syphilology. The tablet recalls his research on the use of bismuth in the treatment of syphilis and on vaccination by the buccal route. At the ceremonies held in connection with the event, Professor Brindeau, chairman of the committee that sponsored the erection of the tablet, traced the career of Dr. Fournier before a group of former pupils and friends.

RECENT DEATHS

DR. SPENCER TROTTER, formerly professor of biology at Swarthmore College, died on April 11, in his seventy-second year. After teaching for thirty-eight years, Dr. Trotter retired in 1926.

PROFESSOR GEORGE SEVERANCE, head of the department of farm management and agricultural economics and vice-dean of the College of Agriculture, State College of Washington, Pullman, died on March 8. Professor Severance graduated from the Michigan Agricultural College in 1901, and in 1901–02 he was instructor in agriculture at that institution. In 1902 he went to the State College of Washington as instructor in agriculture and served at that institution in various positions of responsibility with only a little more than one year's interruption until his death.

DR. JOHN ANDERSON, known for his work on cerebro-spinal meningitis, died at Shanghai on March 30. At the time of his death Dr. Anderson was head of the division of medicine at the Henry Lester Institute for Medical Research, Shanghai. Previously he had been professor of medicine at Hongkong University and a Wandsworth Fellow of the London School of Tropical Medicine.

DR. WILLIAM C. MACINTOSH, a student of marine invertebrates, formerly director of the museum at the University of St. Andrews, Scotland, has died, at the age of ninety-two years. Dr. MacIntosh had held positions on many government committees dealing with the shell-fisheries of the British Isles.

SCIENTIFIC EVENTS

THE CALCUTTA INSTITUTE OF HYGIENE AND PUBLIC HEALTH

AN article in the *British Medical Journal* on March 28 gives a description of the newly established Institute of Hygiene and Public Health in Calcutta. The proposal to establish a School of Tropical Medicine in Calcutta and an Institute of Hygiene at Bombay was first made by Dr. Leonard Rogers in 1914. Six years later the Calcutta School of Tropical Medicine and Hygiene, in which teaching and research were combined, was opened. At that time a chair of hygiene was established, and a course of instruction arranged for the university diploma of public health, but this provision was soon seen to be inadequate. It was recognized there would be an increasing need, in all the Indian provinces, for specialists and workers highly trained in general hygiene, with knowledge and experience of Indian requirements. This need was emphasized by Major General J. D. Graham in his annual report as public health commissioner in 1925, and by Major General Megaw, head of the school. They discussed their plans with Dr. W. S. Carter, associate director of the Rockefeller Foundation, during his periodic tours of India and as a result the Rockefeller Foundation offered to meet the cost of acquiring the site, and to build and equip an institute on an assurance from the government that it would defray the cost of staff and maintenance after the building was handed over.

In July, 1930, a site was acquired, and building was begun in September. A constructional committee was appointed, consisting of the public health commissioner with the Government of India, the surgeon-general with the Government of Bengal, the chief engineer with the same government, the chairman of the Calcutta Improvement Trust, and the Accountant-General, Bengal. Lieutenant-Colonel A. D. Stewart, professor of hygiene in the Calcutta School of Tropical Medicine, was appointed director-designate of the new institute, and Lieutenant-Colonel A. A. E. Baptist, assistant director, to superintend the construction and equipment. It is expected that the building will be completed by the end of this year, and that the institute will be opened for work early in 1932.

The site of the institute practically adjoins the school, with which the building will harmonize in design and appearance. The plan is based on a unit room of 25 ft. by 21 ft. The building, which will be E-shaped and four-storied, the long limb being in the center, will accommodate six sections: (1) public health administration; (2) sanitary engineering; (3)

vital statistics and epidemiology; (4) biochemistry and nutrition; (5) malariology and rural hygiene; and (6) maternity and child welfare and school hygiene.

Each section will be staffed by a professor, an assistant professor, and laboratory or other assistants. As the chief object of the institute is to bridge over the gulf between the results achieved by pure research and their practical application to the community, its function will be primarily instruction. The subjects for the D. P. H., Part I, will continue to be taught at the Tropical School, but the specialized subjects in public health will be taken by the staff of the institute. The examination for the D.P.H. is conducted by the University of Calcutta, with which the new institute will be affiliated in due course. It is also intended to provide short post-graduate instruction in special subjects for public health workers desiring to pursue advanced study, and it is probable that the university will institute a higher degree or doctorate in public health science, which will require a year's training at the institute in some specialized branch. Special courses in child welfare and public-health nursing may be arranged for women graduates and nurses, respectively. The institute will be coordinated with the various aspects of practical hygiene and public health all over India.

FIELD EXPEDITIONS OF THE SMITHSONIAN INSTITUTION

ACCORDING to a press release from the Smithsonian Institution field expeditions during 1930 touched upon every continent and many islands of the sea, besides visiting 23 states of the United States, according to its annual illustrated pamphlet, "Explorations and Field-work of the Smithsonian Institution in 1930," just issued. The subjects of investigation by these expeditions were as varied as the localities visited; they included the radiation of the sun, microfossils—those minute organisms of great value in determining oil zones in the earth's crust, the ancient Eskimo culture of Alaska, Indian music, the animals and plants of the interior of China, the birds of Spain, fossil horses in Idaho, silver minerals in Canada, the plants of South Africa and many other subjects. From all these expeditions, large collections have come in to the U. S. National Museum for study and in some instances for exhibition to the public.

Dr. Aleš Hrdlička devoted the summer months of 1930 to a study of the ancient and modern Eskimo population along the Kuskokwim River, the second largest in Alaska. This area has never before been visited by a physical anthropologist, and Dr. Hrdlička's work led to valuable conclusions.

In continuation of his "fossil horse round-up" in Idaho, Dr. J. W. Gidley spent the field season in working the fossil bone deposit near Hagerman, Idaho. The deposit was probably at the time it was formed a watering place for the wild animals of the region, for it contains the bones of hundreds of animals, mostly belonging to an extinct species of horse. This deposit is considered one of the important paleontological discoveries of recent years, for it contains abundant remains of the rare extinct horse, *Plesippus*, an animal intermediate between the present-day horse and the three-toed horse of more ancient time. Sufficient material was collected to restore three or four complete skeletons.

Lieutenant Henry C. Kellers, U.S.N., was detailed to act as Smithsonian representative on the U. S. Naval Observatory Eclipse Expedition to Niuafou Island of the Tonga Archipelago, in the South Seas. This island is commonly known as "Tin-can Island," for so rocky and precipitous is the shore that mail can only be delivered from the mail steamer by enclosing it in a sealed can and throwing the can overboard, where it is picked up by native swimmers and towed to shore. Dr. Kellers, with the aid of the natives, succeeded in collecting many of the unusual life forms of the island, over 7,000 specimens being sent back to the National Museum.

Twenty-nine separate expeditions of 1930 are described in the Smithsonian's publication. All are described in the words of the field-workers themselves and all are illustrated by photographs taken in the field.

MEETING OF THE NATIONAL ADVISORY HEALTH COUNCIL

THE field and laboratory investigations being conducted by the U. S. Public Health Service were surveyed, according to the New York *Herald-Tribune*, on April 10, and generally approved by the National Advisory Health Council, a body consisting of internationally known authorities in various fields of scientific endeavor related to the work of the Public Health Service established recently under an act passed a year ago. It organized in executive session on April 9 and had its first meeting with members of the government staff.

Carrying out its function of talking over the research problems of government investigators and advising them, the members of the council heard members of the field force of the health service and of the staff of its national institute of health. The council replaces on an extended scale the old advisory board, which performed similar functions for the hygienic laboratory before it was made the nucleus of the national institute.

Its members include Drs. William H. Welch, of the Johns Hopkins University; Haven Emerson, of Columbia; C. E. A. Winslow, of Yale; M. P. Ravenel,

of the University of Missouri; W. H. Howell, of Johns Hopkins; Alfred Stengel, of the University of Pennsylvania; Captain C. S. Butler, U.S.N.; Colonel P. M. Ashburn, of the Army Medical Corps; Drs. John R. Mohler, of the Bureau of Animal Industry of the Department of Agriculture; George W. McCoy, director of the National Institute of Health; L. R. Thompson, assistant surgeon-general of the Public Health Service in charge of research, and Hugh S. Cumming, Surgeon General, chairman.

Cancer research, which is being conducted by the Health Service more extensively than ever before, was discussed with the council at some length. This work not only has been expanded under increased appropriations, but is to be extended further, and the government scientists asked the benefit of the council's advice in that undertaking.

Field work on leprosy, particularly in Hawaii, was also discussed, together with studies of malaria, Rocky Mountain spotted fever, which recently has invaded the east; child hygiene, industrial hygiene and sanitation, milk sanitation, stream pollution and statistical analysis of different public health problems.

Investigations discussed included work on certain phases of cancer, diphtheria prevention, meningitis, nutrition, infantile paralysis, scarlet fever, trachoma, tularemia, typhus, undulant fever, etc. Work on sociological problems, including studies of parasites and animal hosts, at the institute, and special chemical studies related to public health problems also were discussed.

RESEARCH AT THE MELLON INSTITUTE

In his eighteenth annual report to the board of trustees of Mellon Institute, Director E. R. Weidlein has summarized the activities of the institution during the fiscal year ended February 28, 1931. The sum of $805,204 was contributed to the institute by the industrial fellowship donors in support of scientific research. The total amount of money appropriated by companies and associations to the institute for the twenty years ended February 28, 1931, was $7,554,477.

Throughout the entire fiscal year 76 industrial fellowships—22 multiple fellowships and 54 individual fellowships—were in operation. During the preceding year the number of fellowships was 71. In 1930–31, 140 industrial fellows and 49 assistants held positions on the research staff. Sixty-four industrial fellowships (17 multiple fellowships and 47 individual fellowships)—three more than on February 28, 1930—were active at the close of the fiscal year. Nine fellowships are being sustained by industrial associations. The industrial research personnel consists of 109 fellows and 31 assistants. Thirty-one fellowships have been in operation for five years or more, and of this number 18 have concluded more than ten years of work. Three and possibly four new fellowships will begin operation during the early part of the present fiscal year—just as soon as laboratory space is available.

According to the report particularly noteworthy results have come from the following fellowships: Air pollution, by-product coke, face brick, fertilizer, heat-insulation, iodine, nitrogenous resins, organic synthesis, refractories, sleep and utensil. Twelve fellowships completed their research programs, namely, chrome ore, insulating lumber, Portland cement, composite glass, yeast, inhibitor, steel treatment, rock products, roofing, fatty acids (uses), oxygen and face brick. Thirteen new fellowships were added to the institute's roll during the fiscal year, as follows: Safety fuse, plastic composition, bread, cottonseed products, hydro-engineering, abrasives, newsprint, sugar, fatty acids (synthesis), shoes, optical glass, commodity standards and tire bead.

The department of research in pure chemistry had a productive year and two fellows were added to the staff. Twenty-two investigational reports have been published since the establishment of this department in 1924. Among the subjects that are receiving research attention are the chemistry of marine plants, cherry gum, gum arabic and quince-seed mucilage, and the properties of the sugar acids.

The publications by members of the institute during the calendar year 1930 included 1 book, 5 bulletins, 45 research reports and 44 other papers. Sixteen U. S. patents and 13 foreign patents were issued to fellowship incumbents. The total contributions to the literature for the nineteen years ended January 1, 1931, have been as follows: 16 books, 101 bulletins, 573 research reports, 893 other articles, and 423 U. S. patents. These publications are listed in the institute's Bibliographic Bulletin No. 2 and its four supplements.

The commencement of the construction of the institute's new home is referred to as the most important event during the year covered by the report. Early in May, 1930, it was decided that, as the present two buildings of the institution are inadequate for the immediate and future needs of its departments and industrial fellowships, a commodious modern structure would be built at the corner of Fifth and Bellefield Avenues, Pittsburgh. The excavating work, which was started on November 5, was finished in March (97,000 cubic yards of soil being removed) and the foundation is now being constructed.

The erecting of this edifice will require about two years' time, and the completed building will furnish the institute with the means for expanding greatly

its research facilities and activities in both pure and applied science. The structure, which will be of that type of classical Greek architecture known as Ionic, will be built of granite and Indiana limestone; it will be plain but massive, and will be surrounded by 62 monolithic columns. The proportions of the building will be approximately 300 feet by 275 feet, and there will be eight working floors.

SCIENTIFIC NOTES AND NEWS

DR. WERNER HEISENBERG, professor of theoretical physics at the University of Leipzig, has been awarded the Barnard Medal of Columbia University. Every five years the National Academy of Sciences recommends to the trustees of Columbia University a nominee for the Barnard Medal "for discoveries in physical or astronomical science or novel application of science to purposes beneficial to the human race." The previous recipients of the medal have been Sir Ernest Rutherford, 1909; Sir William H. Bragg, 1914; Professor Albert Einstein, 1921, and Professor Niels Bohr, 1925.

THE Institution of Chemical Engineers, London, has conferred the Osborne Reynolds Medal for 1930 on the retiring president, Mr. Arthur J. Reavell; the Moulton Gold Medal on Mr. A. T. King for his work on the treatment of suint liquors, and the silver Junior Moulton Medal on Mr. L. W. Blundell for a paper on the manufacture of hydrogen peroxide.

THE University of Manchester will confer the doctorate of laws on Dr. Arthur Harden, professor of biochemistry in the University of London, and the doctorate of science on Sir James Jeans.

DR. WILLIAM H. WELCH, professor of the history of medicine at the Johns Hopkins University, observed his eighty-first birthday on April 8.

AT the close of the annual meeting in Richmond of the Virginia section of the American Society of Bacteriologists, a dinner was tendered in honor of Dr. William H. Park, chief of the research laboratory of the New York City Health Department.

A LUNCHEON in honor of Mr. Max von Bernewitz, retiring secretary of the Pittsburgh section, American Institute of Mining and Metallurgical Engineers, was tendered to him on April 9 by the engineers of Pittsburgh. Mr. von Bernewitz has joined the staff of the Bureau of Mines at Washington.

A DINNER in honor of Dr. James H. Kimball, head of the New York office of the U. S. Weather Bureau, was held in New York City on April 9, at which he was presented with a medal and scroll. The following telegram was received by the committee in charge from President Hoover: "I will be obliged if you will express my cordial greeting to those present at the dinner in honor of Dr. James H. Kimball, and to Dr. Kimball himself my warm appreciation for his signal services in promoting the success of aviation in general and transatlantic flights in particular through his scientific skill and judgment so characteristic of the entire weather forecasting service of our country." Telegrams were also read from Dr. Hugo Eckener, Maurice Bellonte and others who have benefited by Dr. Kimball's advice. Admiral Byrd gave Dr. Kimball a silk flag that he said he had carried over the Atlantic, and also on his flights in Antarctica. Dr. Charles H. Marvin, chief of the U. S. Weather Bureau, was among the speakers.

PROFESSOR R. A. BUDINGTON and Professor C. G. Rogers, of the department of zoology of Oberlin College, have been honored at Fukien Christian University in China. A donor who wishes to remain anonymous has created at the university two scholarships which are named after the Oberlin faculty members "in appreciation and respect."

THE *Journal* of the American Medical Association reports that to observe the tenth anniversary of the discovery of insulin by Drs. Frederick G. Banting and Charles H. Best, Toronto, a course on insulin and its use, organized by the extension division of the University of Wisconsin, at the request of the State Medical Society, will be given during the week of May 18 for one day each in Madison, Milwaukee, Oshkosh, Wausau, Eau Claire and La Crosse. Dr. Leland S. McKittrick, Boston, and Dr. Russell M. Wilder, of the University of Chicago, will, with Dr. Elmer L. Sevringhaus and a dietitian of the Medical School at Madison, give lectures and demonstrations.

THE Paul Ehrlich-Stiftung has awarded Professor Levaditi, of the Pasteur Institute in Paris, the Paul Ehrlich gold medal for 1931, for his researches in the field of chemotherapy; also two money prizes to Professor Hugo Braun, head of the hygienic institute of the University of Frankfort-on-Main, and to Dr. Walter Levinthal, head assistant at the Robert-Koch-Institut in Berlin, respectively, for their researches on the metabolism of bacteria and the virus of psittacosis. The prizes were bestowed with fitting ceremonies in Frankfort-on-Main, on Ehrlich's birthday on March 4.

IT is stated in *Nature* that a new article of association of the Royal Zoological Society of New South Wales, giving the council power to confer the title

"fellow" on any member or associate member of the society who has rendered distinguished service to Australian zoology, has recently been formulated. The council has conferred this title upon R. J. Tillyard, H. J. Carter, W. W. Froggatt, T. Iredale, A. F. Basset Hull and T. C. Roughley, all of whom have contributed largely to scientific journals articles dealing with the various branches of Australian zoology.

Dr. E. M. Gress, state botanist of Pennsylvania, was elected president of the Pennsylvania Academy of Science at the close of the seventh annual meeting; Dr. S. H. Williams, of the University of Pittsburgh, was made vice-president and H. W. Thurston, State College, treasurer.

Professor Dugald C. Jackson, head of the department of electrical engineering at the Massachusetts Institute of Technology since 1907, was reelected chairman of the National Research Council's Division of Engineering and Industrial Research at a meeting of the division recently held in New York City. The two vice-chairmen, Dr. David S. Jacobus and Dr. Byron E. Eldred, the director, Dr. Maurice Holland, and the secretary, William Spraragen, all of New York, also were reelected.

Dr. Reuben Peterson has resigned as professor of obstetrics and gynecology at the University of Michigan Medical School, which chair he has held since 1901. A group of men who have served as his assistants during his service on the medical faculty recently presented his portrait to the university. Dr. Peterson will continue his medical practice in Ann Arbor.

Dr. Alfred Hume, chancellor of the University of Mississippi at the time of the political dismissals by authority of Governor Bilbo, and this year professor of mathematics in Southwestern University, Memphis, Tennessee, has been named president of Branham and Hughes Military Academy, Spring Hill, Tennessee. Dr. Hume received the doctorate in science from Vanderbilt University in 1890.

Mr. B. F. Dana, plant pathologist with the Texas Experiment Station since 1927, with headquarters at Temple, Texas, where he conducted research on the cotton root rot disease, has resigned to accept a position as plant pathologist with the U. S. Department of Agriculture, Office of Horticultural Crops and Diseases. Mr. Dana will work on the virus disease, known as "curly top," of vegetables. He has already started his new work with headquarters at the Oregon State College, Corvallis.

C. R. Hoerner, for some time northwest representative for the Niagara Sprayer Company, has resigned to accept a position as plant pathologist with the U. S. Department of Agriculture, Office of Drug and Related Plants, to work in cooperation with the Oregon Experiment Station on the downy mildew of hops in the northwestern states. Mr. Hoerner's headquarters will also be at the Oregon State College.

It is announced by the Northern News Service, as quoted in *Nature,* that Dr. Hjalmar Broch, director of the marine biological station of the University of Oslo, has been appointed by the Jugoslav Government to be director of the Institute of Deep-sea Research and Fishery Investigations in the Adriatic. The Jugoslav Institute is being built at Split (Splalato), where all branches of science concerning deep-sea research will be represented, including zoology, botany and oceanography. Local methods of fishing will also be investigated, with the view of modernizing and rationalizing these.

Mr. H. R. Surridge has been appointed by the British government agricultural officer in Fiji, and H. E. Box entomologist in Antigua.

Dr. C. M. Huffer, assistant professor of astronomy at the University of Wisconsin, will exchange posts with Dr. C. T. Elvey, of the Yerkes Observatory, for a period of two months which started on April 7. Professor Huffer is making a study of the colors of stars and the exchange will give him opportunity to continue his work with the aid of the 40-inch telescope of the Yerkes Observatory.

Dr. William Allen Pusey, past president of the American Medical Association, left for Mexico City on March 21, to discuss plans for Mexico's participation in the Century of Progress Exposition, to be held in Chicago in 1933.

Dr. Malcolm H. Soule, of the Medical School of the University of Michigan, has returned to Ann Arbor from the School of Tropical Medicine in San Juan, Porto Rico, where he has been a visiting professor and special investigator for the past three months.

Dr. C. D. Ellis, of the Cavendish Laboratory, University of Cambridge, has been appointed a member of the staff in physics for the 1931 summer session at Cornell University. Dr. Ellis, who is an authority on β- and γ-ray radiations, will give courses covering the general field of radioactivity with particular emphasis upon nuclear structure and will devote a portion of his time in assisting a small group of investigators to become acquainted with the technique of radioactive work.

Professor Edmund Landau, of the Mathematical Institute of the University of Göttingen, is expected to arrive in New York on April 24, on his way to California, where he will lecture during the summer at Stanford University. He will remain in New York for several days after his arrival and has accepted

an invitation to lecture at Columbia University on April 27 on "Binary Linear Forms." Professor Landau is an authority on the analytic theory of numbers and on the theory of functions.

THE following will be visiting members of the faculty of chemistry of the Ohio State University during the summer session of 1931: Professor Harry B. Weiser, of the Rice Institute, in colloid chemistry; Professor R. C. Fuson, department of chemistry, University of Illinois, in organic chemistry, and Professor Guy Mellon, of Purdue University, in inorganic chemistry and bibliography.

AT the University of Pittsburgh, Dr. A. Lande, recently appointed professor of theoretical physics at the Ohio State University, delivered a lecture on March 12 on "The Quantum Theory of Abnormal Mean Free Paths," under the auspices of the department of physics and the Physical Society of Pittsburgh, and Dr. G. W. Stewart, head of the department of physics of the University of Iowa, delivered a lecture on "The Nature of the Liquid State" on March 26.

DR. CHRISTIAN A. RUCKMICK, professor of psychology at the University of Iowa, will give a series of lectures on the "Facial Expression of Emotion" and the "Galvanic Technique in the Investigation of the Affective Processes" during April on a tour to the Pacific Coast. The institutions visited include the University of Nebraska, the University of Denver, the University of Utah, the University of Southern California, the University of California, College of the Pacific, Stanford University, the University of Oregon, the State Normal College at Bellingham, Washington, Whitman College and the University of Montana. On March 20, Dr. Ruckmick lectured at Northwestern University.

PROFESSOR S. P. FERGUSSON, of the United States Weather Bureau and aerologist of the University of Michigan Greenland Expeditions, will give a semi-popular course of lectures at the University of Michigan under the general topic, "Data and Problems of Aerology." These lectures are given under the joint auspices of the College of Engineering and the department of geology and will begin April 20 to continue through two weeks.

DR. COLIN G. FINK, professor of electrochemistry at Columbia University, recently lectured before the American Chemical Society Sections of North Carolina, Alabama and Syracuse, N. Y., the topics chosen being the "Electrochemical Restoration of Ancient Bronzes," "Corrosion" and "Recent Advances in Applied Electrochemistry." In May he will address the Lehigh Valley Section on "Alloy Anodes and Alloy Cathodes."

DR. HARLAN T. STETSON, director of the Perkins Observatory and professor of astronomy at the Ohio Wesleyan University, will give a lecture on April 24 on "Astronomy and Electricity" before a joint meeting of the New York Section of the Institute of Electrical Engineers and the New York Electrical Society. The lecture will be given in the Engineering Auditorium at 8 p. m.

PROFESSOR A. G. SHENSTONE, of Princeton University, spoke at the Bartol Research Foundation of the Franklin Institute, Swarthmore, Pennsylvania, on March 13, on "Recent Researches in Spectra."

DR. E. W. NELSON, for eleven years head of the United States Bureau of Biological Survey, recently visited the Scripps Institution of Oceanography of the University of California, where he gave an informal talk to members of the staff on his experiences in collecting specimens from this country and Mexico.

DR. KARL J. FREUDENBERG, Carl Schurz memorial professor of the University of Wisconsin, is delivering a series of eighteen lectures at universities and chemical associations of the United States and Canada. Professor Freudenberg will lecture on "Optical Activity and Configuration," "Insulin," "Some Aspects on the Constitution of Cellulose and Other Carbohydrates," "Lignin," "Vegetable Tannins" and "Recent Chemical Evidence on the Constitution of Cellulose."

THE Second International Congress for Light Therapy will be held in Copenhagen from August 15 to 18, 1932, under the presidency of Dr. Axel L. Reyn. The purpose is to study all questions relating to biological and biophysical researches in connection with light and light treatment. Further information may be had from the secretary-general, Dr. A. Kissmeyer, Finsens Lysinstitut, Copenhagen.

ESTABLISHMENT of a fellowship in the Department of Engineering Research for the study of problems in the distillation of petroleum carbohydrates was announced by the regents of the University of Michigan at their last meeting. The grant will be known as the M. W. Kellogg Company Fellowship in Chemical Engineering, and will consist of $1,000 a year for two years. Mr. M. J. Kellogg, of Jersey City, N. J., made provision for the fellowship.

BY the will of the late Professor John Henry Comstock, Cornell University receives the bulk of his estate. The will directs the establishment of the Grove Karl Gilbert loan fund for self-supporting students. The Comstock Publishing Company, which issued books on nature study, also goes to the university. The Ithaca Memorial Hospital and the Unitarian Church receive $1,000 each. The will was made jointly with that of Mrs. Anna Botsford Comstock, who died in August, 1930.

UNDER the will of the late Thomas L. Gray, the Royal Society of Arts has been appointed residuary legatee of his estate for the purpose of founding a memorial to his father, the late Thomas Gray, C.B., who was for many years Assistant Secretary to the Board of Trade (Marine Department). The objects of the trust are "The Advancement of the Science of Navigation and the Scientific and Educational Interests of the British Mercantile Marine." The council now offers the following prizes: A prize of £100 to any person who may bring to their notice a valuable improvement in the science or practice of navigation proposed or invented by himself in the years 1930 and 1931. A prize of £100 for an essay on "The stability of ships, with special reference to the particulars which should be supplied by shipbuilders, and also the value of any mechanical devices for ascertaining the M. G., with which you are acquainted." Further information may be obtained from the Secretary, Royal Society of Arts, John Street, Adelphi, London W. C. 2.

FOR the twenty-third consecutive season the University of Michigan will maintain its summer station for instruction and research in biology from June 29 to August 22, on the shores of Douglas Lake, Cheboygan County. Because of its natural surroundings, the Douglas Lake site offers unique opportunities for pursuing a variety of problems in biology. To the north of the camp is a region of evergreen coniferous forests, while to the south are hardwood forests, making the station the best situated in this respect of any in the country. Lowlands near the lake furnish a variety of plants, including orchids and insect catching types, while Cecil Bay and Big Stone Bay on Lake Michigan are not too distant for study of forests free from fire for fifty years. Bird and animal study is facilitated by the wide variety of natural conditions. A beaver colony with three dams is near by, and 150 species of birds are found in the region in summer. Invertebrate fauna, mollusks, both land and aquatic, crustacea, insects and examples of animal parasites are numerous and well suited to study.

DISCUSSION

A METHOD FOR EXPLANTING THE KIDNEY

ACCURATE determinations of the physiological activities of the kidney require that successive samples of blood be drawn from the renal vein in healthy, unnarcotized animals. A suitable technique for attaining this end has long been desired but has been difficult to evolve. Certain surgical procedures have been carried out in animals under ether anesthesia in an attempt to solve the problem.

Both rabbits and dogs have been employed as experimental animals. In preliminary trials, the left kidney was brought out through a small lumbar incision and the skin and muscle layers were lightly closed around the pedicle. Protection from trauma and drying was afforded by the use of a simple but effective dressing, and after a considerable period, epithelium grew in from the edges of the skin, eventually covering the entire organ. Following removal of the right kidney, animals so treated have remained in perfect health for more than a year. It was found, however, that an excess of granulation tissue formed about the base and prevented easy access to the vessels. This procedure was therefore abandoned, and an effective operative technique substituted.

Dogs were found to be more suitable for these tests. In these animals it was possible to bring out the kidney through a simple, muscle-splitting, lumbar, flank incision and to close the muscle layers loosely around the pedicle. The organ was then tipped posteriorly to render the renal vein as prominent as possible, and a flap of skin was brought down over the organ from the dorsal side and so sutured as to make the position of the kidney a permanent one. Then a strip of skin was cut and sutured down to the subcutaneous tissue on either side of the renal vein. leaving the vein covered by and enclosed in a gutter of skin which was semi-circular in cross-section.

The wounds healed by first intention, and within ten days the right kidney could be removed safely. With the removal of the right kidney, a carotid artery was usually explanted in a tube of skin in accordance with the method described by Cohn and Levy. This was done to facilitate arterial puncture and to obtain constant records of blood pressure.

The technique described herewith has been carried out on forty-five animals, the first of which are now six months post-operative, in excellent health, and without evidence of renal insufficiency as evidenced by alterations in blood chemistry.

By explanting kidneys in the manner outlined above, it has been possible to determine renal circulation, urea excretion and utilization of oxygen by the kidney under a variety of conditions.

C. P. RHOADS

THE HOSPITAL OF THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH, NEW YORK CITY, N. Y.

CENTRAL BODIES IN THE SPERM-FORMING DIVISIONS OF ASCARIS

THE early investigations of O. Hertwig, Brauer, Boveri and others have long been regarded as estab-

lishing the identity of the centrioles seen in the sperm-forming divisions with the similar ones found in other types of mitosis, including the maturation-division of the egg. This comparison has recently been challenged with the contention that in the sperm-forming divisions the centriole is only secondarily associated with the astral centers, and that it is primarily a blepharoplast for the production of the axial filament of the sperm-tail. A crucial test for this interpretation is offered by *Ascaris megalocephala,* where the mature sperm shows neither tail nor axial filament. It was with this point in mind that the late Professor Robert H. Bowen suggested a reinvestigation of the facts in that animal.

My preparations of the sperm-forming divisions in *Ascaris megalocephala* make it perfectly plain that in all essentials the behavior of the centrioles conforms exactly to the classical scheme. There can be no doubt of the fact, uniformly seen in large numbers of cells, that in the first metaphase the centrioles divide at a time when neither the surrounding centrosome nor the aster show any indication of division. In the early anaphase the centrosome becomes ellipsoidal and divides, each daughter centrosome containing a centriole. It is toward the end of the telophase stage that these daughter centrosomes, each with its centriole, begin their movement to opposite sides of the cell, never losing their identity from this stage to the prophase of the next division.

These facts can easily be demonstrated and with perfect clearness. Since in this animal the sperm has no flagellum or axial filament there is no ground for considering the centrioles as blepharoplasts or as differing in any material way from those seen in the mitosis of other kinds of cells.

These results, confirming in all essentials those of the early cytologists, are to be reported in detail hereafter.

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MORE ABOUT SHIPWORMS

ON my return from the West Indies my attention was called to Dr. W. T. Calman's article, "The Taxonomic Outlook in Zoology," being the address of the president of Section D—Zoology, of the British Association for the Advancement of Science, published in SCIENCE, September 19, 1930. On page 281, Dr. Calman uses the sentence:

> Dr. Bartsch, of Washington, in his "Monograph of the American Shipworms" (1922), simplified his task by the assumption that any species found on the coasts of the American continent must, of necessity, be different from any found elsewhere, and he was thus able to write "n. sp." after twenty-two out of the twenty-nine specific names. It was soon shown, however, by other American zoologists that this assumption was without foundation, and that the most destructive species on both the Atlantic and Pacific coasts of North America was the European *Teredo navalis.*

Personally this note has called for no resentment on my part, but only provoked a smile; yet some of my best friends insist that it requires a "retort courteous," lest it be deemed that silence on my part be consent.

European shipworms, unlike men, are apparently as clannish as American shipworms. American shipworms have been carried by the Gulf Stream from the West Indies to European shores since the Gulf Stream came into existence, or, probably still better, since trees grew and were set adrift in the West Indies by various agencies. These trees have always fallen a prey to shipworm attacks, and American shipworms in such floating timbers have thus paid visits to European shores since time immemorial.

Jeffreys, who has done more work upon European shipworms than any other man, pointed out long ago that in spite of the constant immigrations from American waters none of these sea waifs had succeeded in establishing themselves in European waters. By a study of the extensive Jeffreys collection, which rests in the United States National Museum, I am able to confirm his conclusions. The environmental factors of the two regions are evidently sufficiently delimiting to prevent such colonization.

Why some American authors, and my critic, persist in claiming that European shipworms are less choice in selecting a habitat than the American forms has always been a puzzle to me, and seems explainable only on three grounds: (1) European man has found America good; why shouldn't shipworms? (2) Because we love to cling to ancient concepts and are loath to change them. In the days gone by, due to little comparative material much sloppy work was done in determining shipworms and many names belonging to European species were hastily and wrongly applied to American forms. (3) The game of playing politics in science has recently crept in, it being the belief of some naturalist that if we had only one shipworm, *Teredo navalis,* in all the waters of the world, we could get a better or easier hearing for the forming of an international attack upon this animal. Personally, I do not see that it makes any difference whether there is one species or a thousand species of shipworms. Shipworms, except where cultivated for food, as in Siam, are like the Indians of old, all bad, and undesirable.

I find upon careful study based upon a huge amount of material that shipworms are well-behaved mollusks following the laws of distribution that dominate the other bivalves, and I see no reason or justifi-

cation to change any of the views expressed in Bulletin 122 of the United States National Museum. The mass of material that has come to me since that paper was published is all confirmatory of the views expressed there. I fear, therefore, that Dr. Calman's arrow will prove a boomerang that is bound to return to the sender.

Incidentally I wish to refer the reader to two previous notes of mine published in SCIENCE, bearing upon this same subject: One, "The Status of Teredo beachi and Teredo navalis," a paper which appeared in SCIENCE for June 15, 1923, page 692, and evidently overlooked by Dr. Calman, in which I called attention to the fact that these two shipworms were not only not synonymous but did not even belong to the same sections of the subgenus *Teredo*. I gave in that paper the characters that separate them, so they do not need to be repeated here.

Again, "Stenomorph, a New Term in Taxonomy," published in SCIENCE, Volume 57, March 16, 1923, on page 330.

Quoting again from Dr. Calman:

> Nevertheless, the taxonomy of the group remains in a state of the utmost confusion. There is no agreement as to the limits even of the genera, and the inconstancy of the characters that have been used for the definition of species is plain to any one who studies a large collection.

This cry is not an unusual one. We hear it expressed by specialists in all branches of natural history. Usually it means that the individual thus afflicted has for want of time or inclination failed to go to the bottom of things in his study, and expresses his weariness by saying that things are in "utmost confusion." I have yet to find a species that can not readily be placed in the proper subgeneric group in the classification that I submitted in Bulletin 122, or my subsequent paper, "The Shipworms of the Philippine Islands," Bulletin 100, Volume 2, Part 5, U. S. National Museum, 1927, excepting such cases where new groups that were unknown at the time of the publication of these papers are involved. While I do not claim infallibility, I nevertheless believe that this classification is based upon a sound foundation—shell characters.

The shell, in spite of what some soft anatomists would preach, is the soundest single element that one can use in the classification of mollusca. It is comparable, as far as its value for classificatory purposes is concerned, to the skeleton of mammals, birds, reptiles, batrachians and fishes, that is, the vertebrates. I believe that no one will challenge the use of the skeleton of vertebrates for that purpose, and in mollusks this use is even less assailable, for in the molluscan skeleton, unlike that of the vertebrate, we have the story of the entire ontogeny of the animal engraved upon its skeleton. We are therefore able to see, on a perfect specimen of a shell, the sculptural characters that were impressed upon the parts that develop while the animal was still in the egg or the uterus of the parent, as well as the subsequent additions of characters acquired during the various phases intervening between the egg and senescence. In no other group that I am acquainted with—vertebrate or invertebrate—do we find such a perfect complete story of the life history engraved upon any part of the anatomy of an animal. In the other groups each life stage has its features which are modified or eliminated by subsequent development, while in the molluscan shell we have simply a series of additions with perfect preservation of the preceding stage or stages. I maintain, therefore, that the shell is of prime importance in the classification of mollusca. I may here also add that the geological record is based upon this element.

Likewise do I wish to call attention to another very interesting fact brought out by my Cerion breeding experiments, where we found that crossing *Cerion viaregis* with *Cerion incanum* produced an endless number of mutations in the F^2 generation. The shells of these animals, while they present innumerable changes in sculpture and coloration, would nevertheless be recognized as Cerions by any amateur. Not so the anatomy! The dissection of one hundred of these hybrids has brought to light such changes in the organization of the soft parts that had we soft parts only and no shells to check against, different family or even higher rank might have to be assigned to some of these mutations. The same story was expressed by the dissection of one hundred individuals representing a native wild cross of *Cerion peracuta* and *Cerion tridentata*. These facts will be fully presented in a paper which is almost completed. It is sufficient to simply state here that the facts adduced from this Cerion breeding point strongly to the conclusion that the soft anatomy of mollusks is less stable than the shell. This, combined with the fact that the soft anatomy of animals presents at any one time only the particular age or functional stage of that animal, while the shell has engraved upon it all its history up to the time of its demise. A study of the cytology, embryology metamorphosis, as well as that of the adult characters of a shipworm should, and I hope will, give confirmatory evidence for what I claim as facts presented by the shell.

The classification offered in Bulletin 122 was the first attempt in trying to bring up to date the classification of a group of mollusks that had for some time been seriously neglected. New groups since discovered will require its expansion. Here, as in every

other group we must look for further modifications, as our knowledge of the subject increases, but I am convinced that the basis upon which it is founded is sound.

PAUL BARTSCH,
Curator of Mollusks and Cenozoic Invertebrates
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THE RUSSIAN ACADEMY OF SCIENCES

Homo hominis lupus est.—Old proverb.

The President of the Russian Academy of Sciences, Dr. A. P. Karpinsky, the distinguished geologist, is leaving his post at the academy. This decision is the outcome of his unsuccessful protests against the recent forced decision of the academy to deprive of its membership four academicians, including such historians as S. F. Platonov and E. V. Tarle, whose scientific views have been pronounced by the authorities to be incompatible with their presence in the academy of a communistic state. It is noteworthy that at the same meeting of the academy several foreign scientific workers were elected as foreign members. It appears clear, in the circumstances, that the acceptance of membership of the Academy of U. S. S. R. must involve silent agreement with the basic principle underlying the attitude of the Soviet authorities toward science.—*Nature, March 7, 1931, p. 346.*

I VISITED Russia, Siberia and Russian Turkestan (Usbekistan) in 1927, and gave, in *Nature* of November 19 of that year, a brief account of the biological work as I observed it in the U. S. S. R. I was greatly impressed by the volume and variety of the work done, and the fact that all the scientific men I met were industriously cooperating to increase knowledge and education throughout the country. Even at that time it was declared that the professors holding over from pre-revolutionary times would be replaced by "Red" professors as soon as practicable; but although this appeared ominous, I hoped that the actual results would not be definitely unfavorable to science. My more or less optimistic view resulted from acquaintance with a number of young men and women in course of training in the universities, and presumably destined to do the research and academic teaching of the not distant future. They appeared to be on the whole sensible, enthusiastic young people, whose contacts had been broad enough to free them from excessive political dogmatism. I hoped that they would continue to be governed by the true spirit of science, and saw in them the best hope for the Russia of to-morrow.

The Academy of Sciences at Leningrad, combining the functions of the Royal Society and the British Museum, has been the great intellectual center of the country. In its museum are preserved innumerable scientific treasures, excellently arranged. During the early days of the revolution it took all the efforts of Dr. Karpinsky and his daughter to prevent irreparable damage. As it was, a few bullets came through the windows, but no serious injury was done. When I was there, the academy appeared full of energetic and capable workers, who were glad to exhibit some of the latest results of their investigations. Dr. Karpinsky was presiding over a committee to consider the geological and physical aspects of the proposed railway between Usbekistan and Siberia (Turksib railway), which has since been successfully completed. I did not hear anything to suggest that the scientific men were not doing their very best to aid the country and develop its culture. The venerable Karpinsky, over eighty years of age, was as active as a young man.

Yet, in the midst of all this happy and fruitful activity, there was a note of alarm. It was as though one lived in a country of earthquakes, never knowing what the next hour might bring forth. Every one knew that it was possible to be arrested, usually in the small hours of the morning, and carried off to some place not designated. The brother of one of my best friends had disappeared in this fashion, and although the family found out what had become of him, they could only guess at the cause of his arrest. I believe he has now regained his liberty. I had in my pocket a little note-book, crammed with scientific information, and including addresses of people I had met and a sketch-map of the streets of Irkutsk. An official (not of the academy) who happened to see it was greatly alarmed. What would they do if they found that? Yet it contained nothing whatever of a political nature, and as a matter of fact no one asked to see what was in my pockets. At Tashkent we were asked to meet a lady who had been born in California, but had married a Russian and lived for many years in Turkestan. My wife being an old Californian, they wished to talk over old times. But when we sat down to the meal where this lady should have appeared, a note was brought, stating that she could not come, for reasons she would explain later. When we returned through Russia, we learned that we should cross the Volga about midnight. So my wife and I remained awake, and when we came to the great river got up and looked out of the window. We were about a third of the way across when a soldier with a gun appeared, and ordered us back to bed. This was done as a matter of routine; he did not know who we were.

I cite these various occurrences as typical of the existing state of mind. The government is afraid of the people; the people are afraid of the government. I spoke of this to an intelligent Russian. Yes, he

said, of course, but it has always been so in Russia. That is something to remember. The essential liberty and sense of security we enjoy in this country has never existed in Russia. Our race only attained these blessings through a long struggle lasting many centuries.

Scientific men, as such, have no cause to favor the capitalistic system as against the socialistic. On the contrary, the brotherhood of science is a great universal democracy in which free cooperation is essential for progress. The logic of events is forcing us more and more in the direction of socialistic activities, making us more and more responsible to one another. The socialization of agriculture with large scale production and the use of modern machinery is undoubtedly the only adequate way to feed Russia's millions. For my own part I can certainly say that I have a high regard for the Russian people, and fervently hope that they may win through to a condition of prosperity and happiness.

It seems to me that the government is defeating its own ends. Even those in its inner councils are playing a dangerous game, and may be thrown out, like Trotsky. It is very difficult in the nature of the case for the small group of political dictators to understand what people think of their activities. They may be entirely well-intentioned, but they too easily conceive themselves to be endowed with all wisdom. They follow a dogma which was developed long ago, under different conditions. There is no dictatorship of the proletariat, but only of a few members of that type over the millions of their fellows. Fortunately, there is a limiting factor in the lack of ability of this small council to keep its fingers on all that is going on in such a vast area. In many directions, favorable influences, developing locally, may be observed. But as long as the whole country is in effect subject to army discipline, is visualized by the leaders as at war, the growth of normal and peaceful socialism is to that degree hindered. Science can only prosper where there is freedom to investigate and state the results. It appears to be the duty of scientific men throughout the world to oppose the policy of making the Russian Academy, or the schools of Tennessee, subservient to a dogma. In so doing we do not thereby express any hostility to the dogmatists, or necessarily disagreement with their opinions, but simply the view that it is contrary to the spirit of science to be governed by *a priori* decisions, imposed in the interests of non-scientific groups.

Can we ever convince those whose policy we thus necessarily oppose? It may seem a hopeless task, yet I do not believe that expressions of opinion, prompted by no ill-will toward the country, can be wholly without influence. Times will change, as they have before, and what was hardly hoped for will perhaps be attained. In any case, we can not otherwise than do our best.

T. D. A. COCKERELL

UNIVERSITY OF COLORADO

A CONFERENCE ON HEREDITY AS APPLIED TO MAN

THE following memorandum presented to the White House Conference on Child Health and Welfare and referred by the chairman, Dr. Ray Lyman Wilbur, to the continuation committee of that body, is offered for publication in SCIENCE in the hope that biologists and others will use their influence in favor of a future conference on heredity in relation to man as suggested by the Minnesota group.

Representing a group of biologists of the University of Minnesota, I wish to record the conviction that too little attention has been paid to heredity in this conference. One has but to envisage a conference on farm stock, as contrasted with human stock, to see how great a part heredity would play in the discussions and recommendations of such a body. We believe that the knowledge of heredity already existing offers great possibilities for race improvement—quite as important, in the opinion of many authorities, as the environmental factors to which so much attention has been given. We are moved by the contrast between the very large expenditures of public funds, foundation endowments and private gifts, the enormous amount of social effort of all kinds, exerted on the environmental side, and the comparative neglect of the practical aspects of heredity as applied to man. We feel that heredity deserves far more consideration from philanthropic persons and societies, socially minded individuals, constructive statesmen, than it has ever received.

We are aware of the unsatisfactory present situation of ignorance, of prejudice, of unscientific propaganda. We attribute this situation largely to absence of an authoritative, united declaration on the part of experts in this field. We suggest that there be held, either under governmental or private auspices, a conference in which all phases of this fundamentally important subject may be investigated and discussed as fully and frankly as the environmental side has been at this conference. From such a conference we should hope for an authoritative program leading, as the generations progress, to the realization of what we believe should be the first cardinal declaration of a Magna Charta of Childhood: Every child is entitled to be well born.

In presenting this memorandum it is not our intention to criticize or detract from the work of this conference. We are concerned only with the effort to secure a future authoritative conference devoted to heredity as applied to man.

E. P. LYON,
Dean

UNIVERSITY OF MINNESOTA,
THE MEDICAL SCHOOL

SCIENTIFIC BOOKS

A Textbook of Plant Physiology. By N. A. MAXIMOV, translated from the Russian. Edited by A. E. Murneek and R. B. Harvey. McGraw-Hill Book Company, New York and London, 1930.

THREE Russians and their translators have given us treatises on plant physiology in English within the last twenty years. Of these the one most readable and, one would say, the only one likely to be read by the so-called general public, has drawn little attention. Entitled "The Life of the Plant," by the eminent Timiriazeff, its text fits its title: it is an admirable treatise, in a style now old-fashioned. The second has experienced repeated revisions and additions. "Plant Physiology," by Vladimir Palladin, edited by Livingston, represents, like its predecessor, the voluntary effort of author and Anglicizer. It exhibits the chemicalizing of the science. The third, Maximov's "Textbook of Plant Physiology," edited by Murneek and Harvey, carries the chemicalizing and physical chemicalizing still further, and was produced under the changed conditions in Russia to-day. It is one of the many works which we must expect to see produced in the Russian scientific laboratories, works characterized by the brilliancy and unevenness of the Russian. I will not attempt a disquisition on the character, quality, volume and value of the products of social and economic conditions in which one is not free to follow one's inclination, but in which one is so protected against "loss of the job" that one may be as "crazy" as one pleases. The tangential brilliancy of certain Russian scientific workers at the present moment is, I believe, to be explained in part by two convictions: that they are sure, for themselves and their families, of subsistence and shelter, of a sort; and that, however careful they need be about political matters, they are perfectly and irresponsibly free about other intellectual interests. They may indulge themselves in mitogenetic rays or any other inventions, as they choose! Furthermore, if writing is more to their taste than operating microscopes, microtomes and physiological apparatus, it seems to be a perfectly possible alternative. This may, therefore, account for the stream of Russian "contributions to science," of which we are, I believe, only at the beginning, and which is likely to continue as long as the present Russian economic system.

We have in Maximov's text-book an attempted summary of the essentials of plant physiology to-day. In the case of a translation especial care is called for in discussing a book; but in this instance certain details can readily be attributed to the author and others as readily to the editors. While the author's preface to the English translation states that "the translation of the book" was done at his request by three women in Leningrad and a fellow countryman in this country, the result was "edited" by two Americans. The result is an *American* not an *English* translation. The language is not what the merits of the book justify. Colloquialisms ("ironed out") and awkwardnesses are too frequent. The grammatical error of disagreement of subject and predicate in number is difficult to understand, though surprisingly common in certain areas of this country. To cite two examples: On page 67, "Some geologists, as for instance Vernadsky, attribute*s* to the accumulating power," etc., the superfluous *s* being italicized; and on page 214, "However, very soon there *is* revealed in such cells many irregularities and digressions," etc., where *are* should be used instead. These are not errors in proof-reading, such as the wrong number of a figure cited at the top of page 111; they are errors of speech, localism, perhaps a dialect, but none the less regrettable.

The author is presumably responsible for the illustrations, almost without exception borrowed, never in any sense original, even where greenhouses are photographed for the purposes of this volume. Definition and conception of what constitutes a text-book are individual matters, but where author and editors claim that "The text brings up to date the results of physiological research both in Russia and in the United States," one may reply to this challenge by citing that what in the United States is now generally called photosynthesis is in the book still named carbon assimilation; that there is no mention of carbonates and bicarbonates as sources of carbon, the fifty-year-old doctrine of Liebig being the only one mentioned; that the definition of osmotic pressure on page 109 is a definition rather of turgor pressure than of its cause; that the well-known researches of Sponsler are not mentioned, although they throw light on the subject discussed on page 202; that, like its predecessors, this book pays almost no attention to the second and presumably no less important product of photosynthesis, namely, the oxygen, although one should realize that, unless it is released through a wound, its escape from the tissues which liberate it is inconspicuous, slow and incomplete; that Sir James Dewar is the name of the inventor of the most effective insulators so far produced for laboratory or commercial use and not Dewars. It is unfortunate that

the eminent Hollander Went, and his remarkable son, should have their name Germanized to Wendt; and in this connection one may remark that, while the author is probably right, his complete devotion at this time to the idea of hormones as regulatory influences would be regarded by conservatives as premature, and by most persons as too partisan for the author of a "textbook."

So much for some faults. The excellences of the book are no less marked. The treatment of those physiological processes and relations in which water is so largely involved, as in photosynthesis, absorption and transpiration, is that of the master dealing with facts to which he has made his own contributions. Other parts of the book are more compilatory and involve again the individual sense of perspective. The book is so valuable, so usable, that its faults are the more regrettable.

G. J. PEIRCE

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Introduction à la Biologie Expérimentale. Les êtres organisés. Activités, instincts, structures. By PAUL VIGNON. Preface by M. E. L. Bouvier. Encyclopédie Biologique VIII. Paul Lechevalier, Paris, 1930. Octavo. Pp. viii + 731. 890 figs. 23 pls., 3 in colors. Price 210 frs.

THOSE who have had the pleasure of attending the brilliant lectures of Professor Paul Vignon at the Catholic Institute in Paris will not be surprised at their culmination in a book that is both unique and fascinating. The charm of this versatile guide is irresistible as he conducts us in this book through the fields of animal behavior, protozoology, mimicry and protective resemblance, and the evolution of types by mutation and orthogenesis.

Plentiful, excellent illustrations accompany the story, many of which, especially those on protective coloration and form, including three colored plates, are original. Vignon is a skilful artist.

He is also a thorough-going Aristotelian philosopher. An organism, an organ, any natural phenomenon, is to him an "idea," the expression of ultra-spatial, supernatural control. "The living being is enclosed within a wall behind which the drama of life is enacted." By peering through crevices in this impenetrable fortress, the biologist seeks an inkling into that which is taking place. A plan is in it all; ideas are everywhere, even though some of them are whimsical, such as the monstrously overgrown protuberances of the prothorax in certain leaf-hoppers, which are grotesque and, except as disguises, useless. Yet, in spite of such caprices of nature, nothing is fortuitous nor the outcome of blind mechanism.

Although this philosophy runs like the theme of a symphony through the book, emerging here and there in summaries, the author presents an array of facts from his own observations and the works of others which will be of interest to the psychologist, protozoologist, entomologist and biologist generally.

In the chapters on animal behavior, upholders of the Gestalt-theory and of emergent evolution will find much that is in harmony with their way of thinking; the observations and experiments of Koehler and Jennings, for example, are by no means neglected; but one looks in vain for the name of Jacques Loeb or mention of his theory of tropisms. Naturally the more dramatic incidents in the lives of insects and protozoa are stressed, and they are narrated vividly, but with the careful regard to fact characteristic of a well-trained zoologist.

The mysterious organ-forming "idea" appears in the numerous forms of great beauty in the Radiolaria and in the choice and arrangement of materials for the shells of Foraminifera. No hope is offered that biophysics and biochemistry may eventually explain any of these phenomena, but evolution by mutation is regarded as the way by which organisms proceed toward their goal of utility and beauty. Natural selection, however, is a vain formula; to Vignon orthogenesis, teleological control, is paramount.

The chapter on mimicry, which is defined broadly to include protective resemblances, amply describes the disguises of gastropods, crabs, spiders, and many insects, and is especially valuable because it treats of the flower- and leaf-like Orthoptera to which the author has devoted much research. These include African and Indian mantids which lurk among flowers and turn toward the light and their prey the brilliant colors of their ventral surfaces. Flat expansions of prothorax and coxal segments, colored like flowers, attract small insects into the grasp of the mantid's fore legs.

Even more remarkable are the leaf-like grasshoppers of tropical America, *Pterochroza* and its allies, many of which have been described for the first time by Vignon.[1] The fore wings, even of those which are green, mimic old leaves, with highly variable excised margins and blotches like fungus colonies. These spots are of various sizes in some cases, apparently representing different stages of development of the make-believe fungus.

Other South American grasshoppers of the phaneropterid genus *Pycnopalpa* have great blotches on their green wing-covers, suggesting the ravages of the elm-leaf beetle.

That physiological, physiochemical processes play

[1] P. Vignon, "Recherches sur les sauterelles-feuilles de l'Amérique tropicale," Archives du Muséum, 6, V, pp. 57–214, 1931. 58 figures. 1 pl. en couleurs, 12 pls. en simili-gravure, 12 pls. en phototypie.

a part in wing development and coloration appears not to occur to Vignon, such matters obviously being enveloped in an impenetrable cloud of mystery. He calls attention, however, to the important fact that, in many insects, mimetic structure and the instinct for making use of it develop inseparably. This proves the utility of the mimicry, but can the selectionist show that its possessors have thereby an advantage in the rate of reproduction? This question, likewise, does not interest Vignon, who prefers to think that mimicry "serves to show that Life knows how to introduce something personal and new into nature."

In the final chapter, examples are given of mutations and "orthogenetic series" offered as proofs of evolution. Here are described an example of mutation in *Drosophila,* changes which the wing muscles of Dragon-flies have undergone since the Carboniferous, the strange metamorphosis of the parasitic cirriped *Sacculina,* the change of the reptile's jaw into the bird's toothless beak, of the reptile's scale into the feather, eventually into the gorgeous plume of the bird of Paradise, and finally the evolution of the pine cone into the various types of inflorescence of the higher plants.

Whether looking at the world through mechanistic, organistic, or vitalistic glasses, one can not but admire the vigorous, vivid style, the adequate descriptions and excellent figures of this unique book. Although the experimentalist will find its method deductive and descriptive, rather than that which in America we call experimental, he will find here plenty of problems which seem to require experimental treatment, or he may prefer to turn his imagination into other channels and think of them awhile, as would the poet or artist, simply as ideas.

JOHN H. GEROULD

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN AUTOMATIC BALANCE

DURING the course of studies of the relation of soil moisture to plant growth extending over more than a decade it has been necessary to weigh many thousands of soil samples. We have designed and constructed, with the tools usually available in most laboratories, a simple and inexpensive balance which we believe has unique features and which we have found to increase very materially the speed with which weighing may be made.

The balance, which operates on the displacement principle, is shown in Fig. 1. This balance, which has a capacity of 3 kilograms with a sensitivity of 20 milligrams at full load, is of German make and is on sale by most dealers in laboratory equipment in this country. We are also using our device on an analytical balance. Probably many standard makes of beam balances would serve as well as the one illustrated. It will be apparent from the following description that there are, however, several features which are desirable in the balance to be used as a base for our device. The balance is arranged to weigh an article in the left-hand pan by placing weights in the right-hand pan until the difference in weight is 10 grams or less, which is recorded on the scale *a*. The inequality in weights on the two pans is compensated for by the depression of the plunger *b* in the displacement cup *c,* the plunger being depressed until a quantity of liquid is displaced which is exactly equal in weight to the difference in the loads on the weighing pans. A circular disc *d* of slightly less diameter than that of the displacement cup is attached to the plunger *b*. The disc *d* is to dampen the movement of the plunger, and the plunger assembly with the cup and liquid acts as a dashpot.

The plunger assembly is hung from a yoke *e* which

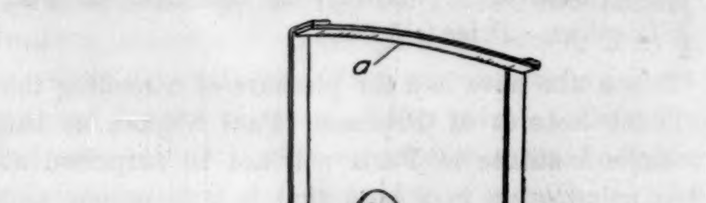

FIG. 1. View from the rear of balance with displacement cup cut away to show plunger assembly. The attachments placed on the stock balance are shown by heavy lines.

is attached to the cross-bar carrying the agate plane for the stirrup and pan hanger. The yoke is pivoted in the cross-bar at points in line with the face of the agate plane by two cylindrical pins so that it can swing freely and its motion be independent of that of the weighing pan. One of the desirable features of the balance is that the stirrup be returned to a fixed position when the knife edges are removed from the agate planes. The beam of the balance must be supported so that it is restrained from horizontal movement and must return to its former position when lowered after being raised. The clearance between the periphery of the disc *d* and the sides of the cup *c* is small, and any considerable movement out of line of the plunger will cause it to stick. The displacement cup *c* is attached to its support *f* by means of lugs which pass through slotted holes so that its position may be changed slightly to center the cup in relation to the plunger assembly.

A spherical concave mirror *g* is attached to the back of the beam of the balance so that its reflecting surface is tangent to a line projected from the central knife-edge. A 3-volt single filament lamp *h* is attached to the back of the balance on an adjustable plate. A small transformer reduces the line voltage from 110 to 3 volts. The lamp is adjusted until the image of the filament is focused on the scale *a* when the beam of the balance is raised. The image of the lamp filament is reflected from the concave mirror *g* down to the plane mirror *i* and thence up to the scale *a* which is attached to a metal piece shaped to the proper arc. The movement of the beam of the balance, then, is greatly amplified. In effect we have a weightless pointer of great length. Furthermore, the angular movement of the beam of light reflected from the concave mirror is twice that of the beam of the balance. The position of the scale *a* may be varied. Raising it increases the length of the scale for a unit weight.

There has long been a prejudice against displacement balances and one reference book, which deals, in part, with weighing machines, states that they are not practical nor accurate. We have met with similar discouragement during the several years we have been attempting to perfect our balance. The failure of the many arrangements we tested was due to the displacement liquid used. Mercury, which, at first thought, would appear to be well suited for this purpose, due to the fact that it will not wet the metal of the plunger or cup, has a low vapor pressure at room temperature and low coefficient of expansion. Mercury, however, has a high surface tension which precludes its use. Pure water, also, has a high surface tension and can not be used. Organic liquids with low surface tensions have high coefficients of cubical expansion which causes some inaccuracies in the balance since the movement of the plunger, and in turn that of the light beam on the scale, depends upon the density of the liquid which changes with the temperature. The properties that an ideal displacement liquid should have are: Low surface tension, low vapor pressure, low viscosity, and low thermal coefficient of expansion.

Water has low viscosity and low coefficient of expansion but it has high surface tension and vapor pressure. However, for some time we used water for the displacement liquid by adding a thin layer of high boiling-point kerosene to reduce the interfacial tension between the water and the metal of the plunger and cup. The evaporation of the water which necessitates frequent additions to the supply in the cup is objectionable. We finally selected a pure organic liquid as the best one available for use in the displacement cup. It has low viscosity, vapor pressure, and surface tension, but, in common with other organic liquids, has a higher coefficient of thermal expansion than water. The variations in the movement of the image of the lamp filament on the scale caused by the change in density of the displacement liquid has been overcome by installing a threaded rod *j* on the arm which carries the pointer and by placing a movable threaded weight *k* on the rod. The deflection of the beam of any balance for a given difference in the loads on the pans varies directly with the distance between the central knife-edge and the end knife-edge and inversely with the weight of the beam and the distance of the center of gravity of the beam below the central knife-edge. Therefore, raising the center of gravity of the beam system increases the deflection. Thus the scale may be lengthened or shortened by moving the weight *k*. The rapidity with which a balance returns to its position of equilibrium after being displaced is influenced by the position of the center of gravity of the beam. In an ordinary balance the center of gravity of the beam must be below the knife-edge, but in our balance it may be above or below because the stability is controlled by the plunger assembly. The weight *k* may be adjusted readily but this need be done only when there is considerable variation in temperature. The change in density of the displacement liquid with temperature variations will cause changes in the rest point of the balance which may be compensated for by means of the adjusting screws. Adjustments due to this cause may have to be made more frequently than the adjustment of the length of the scale. With the present arrangement, the smallest amount of liquid which can be used and still allow the plunger to operate should be placed in the displacement cup.

We are using the balance to weigh accurately to

0.05 gram. The scale and plunger are of such dimensions that 10 grams is indicated on the scale. The loads on the pans have to be balanced to within 10 grams and then the excess in weight is indicated on the scale. However, the scale and plunger can be changed to increase or decrease the portion of the weight which is automatically indicated on the scale. It is rather simple to calculate the diameter of the plunger necessary to give an even multiple or an aliquot part of the scale, and the plungers may be interchanged readily. Since the length of the scale can be changed by adjusting the weight *k,* the calculation of the diameter of the plunger does not have to be exact. We have replaced and used the plunger shown in the sketch with a smaller one so that the entire length of the scale indicates 2 grams only, instead of 10 grams.

The scale divisions are equally spaced throughout the entire length of the scale. The total movement of the beam of the balance is through a relatively small angle, about 5° 55′, and for such an angle the error introduced by equally spacing the scale division is negligible. The scale *a* may be made flat instead of being shaped in the form of an arc, but it is necessary to arc the scale in the balance shown to keep the image of the lamp filament sharply focused throughout the entire range of the scale. On the analytical balance mentioned below we use a flat scale. Another change in the construction of this balance is in the adjustment for the change in rest point due to the contraction or expansion of the displacement liquid which is made by shifting the scale.

Our device has been installed also on an analytical balance of 200-gram capacity. A difference in loads on the weighing pans of 1,000 milligrams or less is indicated on the scale, and the scale can be read easily to 5 milligrams, but it is possible to make the balance more sensitive than this.

The balance has been proven to be simple to construct and operate. It is accurate, and since the movement of the indicating beam of light may be altered at will and the plunger may be interchanged to give different values to the scale divisions, it is extremely flexible and may be employed for a wide variety of weighings. We have found the balance to be very useful in preparing samples of definite weight, since the amount of material to add after the approximate quantity has been placed in the weighing cup is indicated on the scale. The fatigue of weighing is reduced with our balance, and the speed of weighing is greatly increased.

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SECTIONING ORBITOID FORAMINIFERA[1]

THIS fall, wanting to make some careful studies of several different Orbitoids, of which there was only one specimen each available, it was necessary to develop a new technique in order to get both equatorial and vertical sections from the same specimen, the ordinary technique requiring more than one individual.

The technique developed is applicable to all Orbitoids ranging in size above 3 mm in equatorial diameter. The method is as follows:

The specimens were first freed of matrix. Then a common cork about 25 mm in diameter (Fig. 2) was

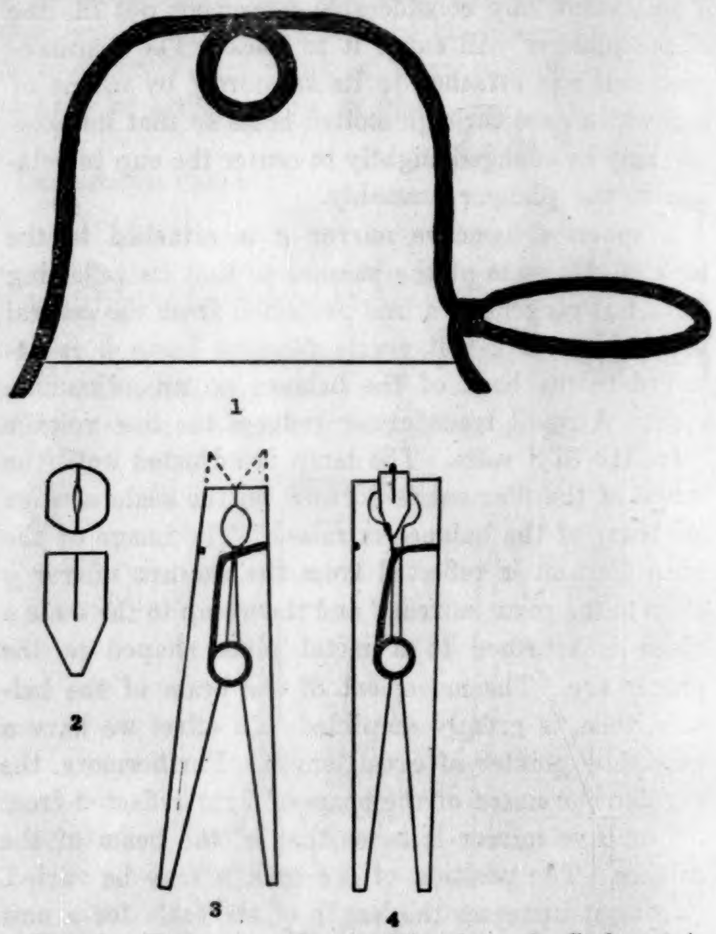

FIG. 1. Fret saw strung with wire. 2, Cork cut to hold specimen. 3, Spring clothes pin with ends cut off as shown by dotted line. 4, Clothes pin, cork with specimen in place to cut.

slit with a sharp blade about two thirds of the way down the center and the sides cut off parallel to the center cut. The lower part was then beveled off to allow it to be grasped in a common spring clothes pin. It is necessary to select a good cork and to cut it parallel with the grain.

The specimen was placed in the cut in the cork for about one half its diameter, the rest sticking out. Then an ordinary spring clothes pin with the ends cut off, as in Fig. 3, was used to hold the cork plus the specimen. I found it best to force a slight depression in the sides of the cork against the specimen so

[1] Method developed during some work done under a grant from the National Research Council.

as to hold it better. Care must be exercised in placing the Orbitoid in the cork so that when the specimen is cut the embryonic apparatus is not damaged. For cutting, a common fret saw frame (Fig. 1) was strung with a piece of No. 10 B & S gauge copper wire under slight tension. This with F.F.F. carborundum and plenty of water was used to cut off a portion of the test. The cut was made as close to the center as possible without damaging the embryonic apparatus. This cutting can be judged only from experience in handling specimens. The wire cuts the test quickly and easily and if due care is exercised in handling the saw, the sawed surface is relatively plane and smooth. The portion cut off is used for a vertical section.

The larger part containing the embryonic apparatus was then mounted in Canada Balsam, as is usually done in making equatorial sections. This part was then ground down on a fine hone; stopping every few strokes to make a Camera Lucida tracing. When the equatorial plane was reached a final tracing was made and measurements of the various parts taken. The Orbitoid was reorientated in additional Canada Balsam as for a vertical section and another series of tracings made, until the embryonic apparatus is again bisected. The cut-off part is then used to make a vertical section in the usual way. There is left a complete vertical section and a piece of the specimen with two polished surfaces; an equatorial and a vertical plane.

The series of Camera Lucida tracings were then drawn on separate sheets of celophane by means of India ink and studied. I have found this method of great use in the study of deformed Orbitoids, especially one that had a twin growing up from one surface. This method is rapid and sure, and it gives a convenient way to study the various chambers of the "larger foraminifera."

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SPECIAL ARTICLES

A POSSIBLE PHYSIOLOGICAL INTERPRETATION OF THE LAW OF THE DIMINISHING INCREMENT

Workers in animal nutrition have long felt the need for some satisfactory means of expressing mathematically the relation between growth and feed consumption. The interpretation of the results obtained in many feeding experiments is often complicated by differences in the amounts of feed consumed by the lots which are being compared. Obviously, it would be very desirable to have some means of calculating the true efficiency of any given feed for growth, regardless of the amounts of feed consumed by the experimental animals.

The applicability of the law of the diminishing increment to the problem of describing the relation between feed consumption and live-weight of growing animals was demonstrated by Spillman.[1] More recently Jull and Titus[2] have shown that the equation as given by Spillman is a fairly accurate means of expressing the live-weight of growing chickens as a function of feed consumption. Titus[3] showed that the growth of ducklings can be described by the equation equally well. Beyond pointing out the fact that each successive gain in live-weight for an equal increment of feed intake tends to bear a constant ratio to the gain immediately preceding, neither of the abovementioned investigators offered any explanation to account for the relationship.

The differential form of the equation of the curve of the diminishing increment is:

$$\frac{dW}{dF} = k(A - W) \tag{1}$$

which merely states that the gain in live-weight per unit of feed intake is directly proportional to the difference between some constant and the live-weight already attained. The constant A has been interpreted to represent the mature weight of the animal, since when growth ceases,

$$\frac{dW}{dF} = O, \text{ and } W = A.$$

No matter how accurately this equation may describe the relation between feed consumption and growth, it throws very little light upon the physiological processes involved unless some rational explanation is presented to show why the equation fits the facts.

It is common knowledge among workers in animal nutrition that the feed intake of a growing animal is utilized essentially in two different ways. One portion is used to supply the fuel required to carry on the metabolic activities of the animal and may be designated as the maintenance requirement.* The other portion is used for growth and part of it is retained and incorporated into the body tissues, pro-

[1] W. J. Spillman and Emil Lang, "The Law of Diminishing Returns," World Book Co., Chicago, 1924.

[2] Morley A. Jull and Harry W. Titus, "Growth of Chickens in Relation to Feed Consumption," *Jour. Agr. Res.*, 36 (6): 541–550 (1928).

[3] Harry W. Titus, "Growth and the Relation between Live-weight and Feed Consumption in the Case of White Pekin Ducklings," *Poultry Sci.*, 7 (6): 254–262 (1928).

* This, of course, includes the energy requirements for all voluntary muscular activity.

ducing a gain in live-weight. It is self-evident that if no feed were required for maintenance and if the fraction of the feed incorporated into the body tissues was always of the same chemical composition, the live-weight of a growing animal would be a linear function of feed consumption. Expressed mathematically the relation would be:

$$\frac{dW}{dF} = C \tag{2}$$

Since some feed is used for maintenance and the amount required for this purpose is known to increase as the animal becomes larger, $\frac{dW}{dF}$ can not be constant but must be some diminishing function of live-weight. It is necessary in this connection to express the amount of feed used for maintenance in terms of a loss of body tissues. If it is assumed that the loss in live-weight per unit of feed consumed is proportional to the live-weight of the animal, we may express the relation between feed consumption and growth as follows:

$$\frac{dW}{dF} = C - mW \tag{3}$$

When this equation is rewritten in the form:

$$\frac{dW}{dF} = m\left(\frac{C}{m} - W\right) \tag{4}$$

it becomes identical with equation (1) for $m = k$ and $\frac{C}{m} = A$.

The integral forms of equations (1) and (4) are, respectively:

$$W = A - Be^{-kF} \tag{5}$$

$$W = \frac{C}{m} - Be^{-mF} \tag{6}$$

in which e is the base of the natural system of logarithms and B is derived from the constant of integration. As pointed out by Spillman, B represents the total possible gain in live-weight of which the animal is capable between its initial live-weight and its weight at maturity.

In accordance with the assumptions made in deriving equation (6) certain conclusions may be drawn from the constants in equation (5). Obviously kA represents the gain in live-weight which the animal is capable of making for each unit of feed eaten if no feed were required for maintenance, for it is readily apparent from equations (5) and (6) that $kA = C$. In other words, kA represents the true efficiency of the feed for growth. It is interesting to note that $\frac{1}{k}$ represents the amount of feed which would have been required for the animal to reach its mature weight if no feed had been required for maintenance, for $kA \cdot \frac{1}{k} = A$ and A represents the live-weight of the animal at maturity.

This interpretation of the law of the diminishing increment may be employed for the purpose of estimating the maintenance requirement of a growing animal at any stage of growth. Let W_1 represent the live-weight of the animal when it has consumed F_1 units of feed. If no feed had been used for maintenance, the live-weight would have been $kA \cdot F_1 + W_0$, in which W_0 represents the animal's initial live-weight. The number of units of live-weight which have been lost because of the maintenance requirement while the animal was attaining the weight W_1 is, therefore, $kA \cdot F_1 + W_0 - W_1$. Since a gain in live-weight of one unit is equivalent to $\frac{1}{kA}$ units of feed, the maintenance requirement, expressed in units of feed, is $F_1 + \frac{W_0}{kA} - \frac{W_1}{kA}$. Similarly, the total amount of feed which has been used for maintenance by the time the animal reaches another live-weight, W_2, is $F_2 + \frac{W_0}{kA} - \frac{W_2}{kA}$. Therefore, the amount of feed used for maintenance during the time the animal is consuming the increment of feed, $F_2 - F_1$, is

$$F_2 - F_1 - \frac{W_2 - W_1}{kA}$$

Jull and Titus, in their work on "Growth of Chickens in Relation to Feed Consumption," give the results of fitting the equation of the curve of the diminishing increment to data obtained from four lots of cross-bred chickens, obtained by mating Barred Plymouth Rock females with Rhode Island Red males. Two of the lots consisted of pullets and two of cockerels, the sexes being separated at hatching time. Although all four lots were fed the same diet and received the same treatment, the duplicate lots did not eat the same amounts of feed. However, the values of kA calculated from the fitted equations agree very well for the duplicate pens as the accompanying table shows.

According to these values the cockerels were able to make better use of the feed for growth than the pullets.

Some idea of the reliability of these results can be obtained by comparing them with a value obtained for white Leghorn pullets recently reported by Titus.[4] In determining the gross maintenance requirement

[4] Harry W. Titus, "The Gross Maintenance Requirement of White Leghorns." *Poultry Sci.* 8(2): 80–84 (1928).

VALUES OF kA CALCULATED FROM EQUATIONS OBTAINED BY JULL AND TITUS

Lot	Sex	A	k	kA (Efficiency of feed for growth)
		Kilograms		
1	Females	3.0726	.0970791	.298
2	Females	3.6084	.0817604	.295
3	Males	4.9142	.0710867	.349
4	Males	4.1954	.0873561	.366

of a group of White Leghorn pullets, having an average live-weight of 1,632 grams, Titus found that a gram loss in live-weight was equivalent to about 3.45 grams of feed. Taking the reciprocal of this value, a gram of feed is found to be equivalent to .290 grams of body tissue. This value agrees very well with the corresponding values calculated for the cross-bred pullets by means of the equation of the diminishing increment.

The writers have calculated the maintenance requirements of chickens at various ages from the above-mentioned data, using the method described above. They appear to be of reasonable magnitude but, unfortunately, no experimentally determined values are available with which to check the results.

If the fundamental assumption that the fraction of the feed incorporated into the body tissues is always of the same chemical composition is valid, the maintenance requirements must be correct. By re-writing equation (3) in the form:

$$dW = C \cdot dF - mW \cdot dF \tag{7}$$

it is readily apparent that the time relationships are as follows:

$$\frac{dW}{dT} = C \cdot \frac{dF}{dT} - mW \cdot \frac{dF}{dT} \tag{8}$$

The maintenance requirement of an animal at any particular time is, according to this equation, proportional to the product of the live-weight of the animal and the amount of feed ingested, which agrees with the well-known fact that the heat production of an animal is increased as its plane of nutrition is raised. During the actively growing period the chemical composition of the animal probably does not change sufficiently to introduce any great error into the calculations.

In view of the number of possible factors which may affect the maintenance requirement of an animal and the relative lack of refinement of the conditions under which feeding experiments are ordinarily carried on, the expression of the maintenance requirement as given in equations (3) and (8) is probably as justifiable as any other proposed up to the present time. However, it should be regarded as being merely a tentative approximation to the true mathematical relationships involved. A better equation expressing the relation between feed consumption and growth can doubtless be evolved when more information regarding the metabolism of the growing animal is available. Until such information is available the law of the diminishing increment may be of much help in the interpretation of the results of a feeding experiment.

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THE RÔLE OF COPPER IN THE SETTING AND METAMORPHOSIS OF THE OYSTER

THE most important and critical period in the life history of the oyster is that during which the fully developed larva cements itself to some clean submerged surface such as old shells or stones and then undergoes a metamorphosis into a spat and adult oyster. The term setting is applied to this process of attachment, which is a biological reaction of a most positive character requiring a definite chemical stimulus for its initiation. A study of the setting reaction under natural conditions in Milford Harbor, Connecticut, showed that it occurred during the low water stage of the tide or, in other words, when river discharge had its greatest effect on the physical and chemical condition of the water over the oyster beds. The environment of the oyster is exceedingly complex from a physical and chemical standpoint, and at periods of low tide we find the extremes of many factors as the mixing of fresh and salt water is taking place. Experiments with the oyster larvae under controlled laboratory conditions showed that changes in temperature, salinity, hydrogen-ion concentration, oxygen content, CO_2 tension and water pressure would not induce in a single instance the setting reaction. However, if in reducing the salinity, river water was used instead of distilled water, the larvae gave a positive setting reaction, which indicated that there was some substance in the river water which served to stimulate and control their attachment and metamorphosis. Further experiments involving variations in the amount and proportion of the cations and anions of the neutral salts were found to be ineffective in producing setting of the larvae, as were also the compounds of iron, zinc, tin, lead, aluminum, manganese and silver. The only element of those tested that produced a positive setting reaction was copper in the form of a pure metal or as a carbonate, sul-

phate or chloride. This heavy metal was effective in concentrations of one part copper to 25 million or 50 million parts of sea water and initiated almost immediately the setting process. In the river water, copper was found to be present in amounts varying from 0.2 mg to 1.25 mg per kilo, and is apparently the specific element that is necessary for the attachment, metamorphosis and survival of the oyster. River water from which the copper had been removed by precipitation and filtration was no longer effective in producing setting.

Conditions in Milford Harbor, Connecticut, were unusually favorable during the past summer for the setting of oyster larvae, so that it was possible to determine under natural conditions the relation between the time and intensity of this reaction and the copper content of the water. Several series of observations were made covering complete tidal cycles, one of which is shown for July 22 in the following figure.

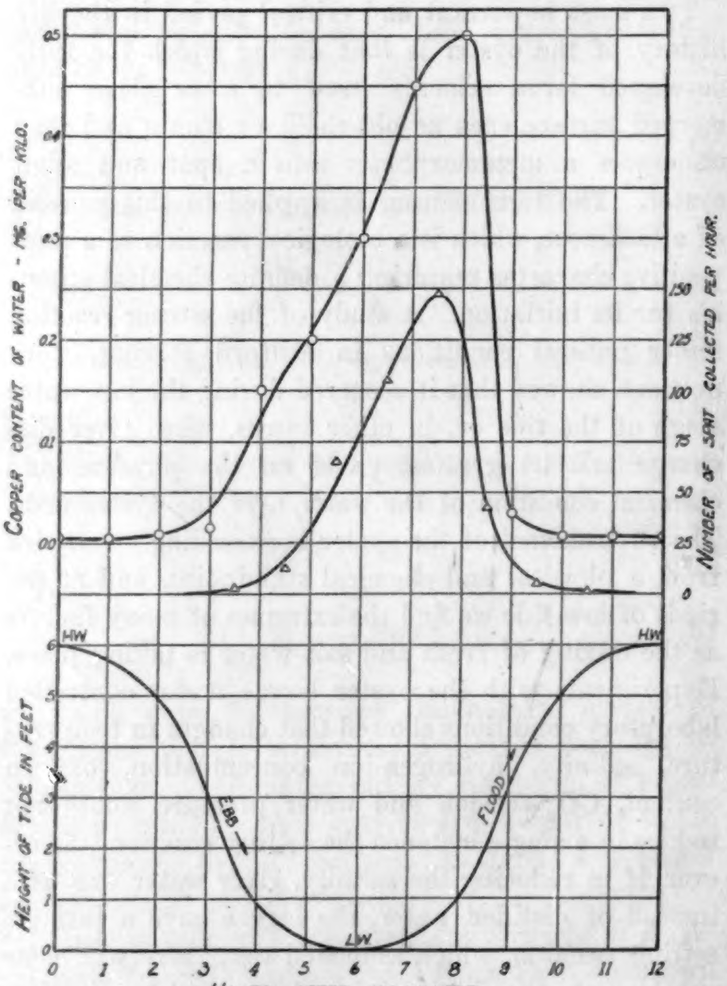

FIG. 1. Relation between the copper content of the water and the setting of oyster larvae.

The intensity of the setting was determined through the use of standard partition collectors for oyster seed, 12 of which were planted under uniform conditions at the time of high water and removed singly every hour thereafter to ascertain the number of spat which they had gathered during each interval. The difference in the number of spat collected from hour to hour shows the relative intensity of setting, during each period, which can be closely correlated with the copper content of the water. A concentration of approximately 380 spat was found on collectors which were left in the water during this complete tidal cycle, and of this number over 97.5 per cent. had become attached during the period when the copper content of the water ranged from 0.15 mg to 0.50 mg per liter.

The water of highest copper content is found in Milford Harbor in the surface layer shortly after the time of low water, while in other regions this relationship may vary according to the existing hydrographical and tidal conditions and thus produce differences in the distribution of oysters and heavy setting areas. The sudden rise in the copper content of the water on the first of flood tide, as shown in the accompanying figure, was due to the upstream movement of water from the Indian River which continues to run ebb into the harbor near the mouth, for an hour or two while the tide there is running flood. Samples of water from the Indian River showed a copper content ranging from 0.8 to 1.2 mg per liter, which clearly accounts for its effectiveness in stimulating the swimming and setting of oyster larvae during low water and the first two hours of flood tide. At the time that this water was passing over the tidal flats there occurred on five acres of this area the setting of over 100 million oyster larvae. However, as the tide rose rapidly above the two-foot mark, the flow from Indian River stopped, as did also the setting of the larvae when they were subjected to water having a higher salinity and a very low copper content of less than 0.01 mg per liter.

Cytological studies of the larvae showed that during its development there were gradually being deposited near the liver two dark green pigmented bodies which disappeared with its metamorphosis into the adult form. These pigment spots on closer examination were found to consist of a mass of densely packed cells, containing numerous green-colored granules, which with the beginning of the setting reaction were observed to gradually break apart and migrate into the blood stream. Approximately 300 of these deeply pigmented cells came from each pigment spot and exhibited such structural and functional characteristics as to identify themselves as the leucocytes of the spat and adult oyster.

Copper plays an important rôle in the respiratory processes of the oyster, and its assimilation by the larva would serve to increase the oxygen-carrying capacity of the blood and release cells during the metamorphosis for carrying out this function, both of which would greatly facilitate its rapid growth and development into the adult form.

Though copper, like other heavy metals, may have a beneficial and stimulating effect in infinitesimal amounts, it will in slightly higher concentrations quickly produce cytolysis and death of the oyster larva.

These studies indicate that in the development, distribution and survival of marine animals traces of certain mineral elements in their environment are of considerable biological significance and may constitute some of the chief limiting factors.

By the use of copper in the form of a pure metal or salt, it was possible in 1928 to observe in detail for the first time the setting and metamorphosis of the oyster larva, a brief description of which has been given in Bureau of Fisheries Document No. 1068 (Progress in Biological Inquiries, 1928).

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EXPERIMENTS IN TERMITE CASTE DEVELOPMENT

FOR many years two main theories have been invoked to explain the production of termite castes. According to one set of advocates the important factors are seated in the germ plasm, while an equally illustrious group of investigators maintain that the worker and soldier castes at least owe their origin to environmental agencies. For several months I have been conducting a series of experiments whose results appear to be pertinent, but as some years will probably elapse before the completion of the work this note is published in the hope that students may be induced to study other species, especially those in which the worker caste is represented.

The material serving as a basis of these experiments are the Pacific Slope species, *Termopsis angusticollis* and *T. nevadensis,* in which only soldiers are developed during the first four years. When, in other words, the colony is approximately four years old, and comprises about four hundred soldiers in various stages of development a few winged individuals, representing the reproductive caste, put in an appearance. As the population increases the two classes gradually become equally represented, and often in old nests, where the food supply is running low, the reproductive caste is practically the only one present. Furthermore, the first soldier developed in a new colony is probably in the fifth instar. The second one is undoubtedly in the sixth, and as the community enlarges the number of molts increases until in long established societies the adult soldiers are in the ninth instar. No exception is known to the rule that the winged or perfect insects make their first appearance only at a point where the soldiers are in the eighth instar. Caste development in the case of *Termopsis,* for the first four years at least, is thus a well-ordered, gradual and invariable series of events, judging by a careful examination of scores of colonies.

It has been demonstrated in the case of certain other insects that within limits the number of molts is dependent upon temperature or the food supply. In the present instance temperature appears to be of minor importance. On the other hand, when the colony is small the food administered to the young is obviously limited, and the fact that the increase in the number of molts bears a fairly definite relation to the increasing number of attendants strongly suggests that food is the important factor. The following experiments also lead to the same general conclusion.

Several large colonies of both species of *Termopsis* were selected in which the reproductive and soldier castes were equally represented. In some cases they were headed by the original king and queen, which were isolated and placed in an experimental jar. An examination six months later showed in every instance that these individuals had died without making an effort to construct a burrow. The remaining colonies were headed by from three to twenty-one substitute or neoteinic royal insects. When the number of these was five or less they were removed from each colony and placed in a separate jar; where the number was larger they were divided into groups of not more than five. Thirty-six such lots have been kept under observation for a period of from two to two and one half years. Four of these died during the period of experimentation; the others evidently set to work almost immediately on the construction of burrows, and evidently commenced to produce young during the first six months. From time to time an individual colony was preserved and measurements taken.

The results show conclusively that when these small groups of kings and queens are deprived of attendants they cease abruptly to produce members of the reproductive caste, and develop soldiers only. And furthermore, the important fact appears that the first soldiers are in the fifth and sixth instars, and the number of molts increases in proportion to the growth of the population. In short, the history of the young colony, headed by a few royal neoteinic insects, is exactly the same as that of the young colony normally headed by the winged king and queen. There is nothing obvious in these experiments which suggests germ plasm as an important factor; rather it appears to be a question of quantitative or possibly qualitative feeding.

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DIOECIOUS MAIZE

In contrast to the higher animals most seed plants are hermaphroditic, having male and female sex organs either in the same flowers or in different flowers on the same plant. There are a number of species of plants, both cultivated and in the wild, that have the two types of flowers in different individuals and correspond, functionally, to the situation in the higher animals. How this condition may have been brought about naturally is illustrated by the change that has been made under experimental control whereby the normally monoecious maize has been changed to a dioecious plant.

A recessive gene called silkless, found in a self-fertilized progeny of flint corn, renders the normal pistillate inflorescence, commonly called the ear, devoid of silks. The ovaries with their styles and stigmas are aborted and the result is a barren cob enclosed in the usual husks. These silkless plants have normal tassels and good pollen and are functionally male plants.

Another hereditary factor is known which changes the terminal staminate flower or tassel of corn into a seed-bearing structure. These "tassel-seed" plants, since they produce good seed but no pollen, are functionally female plants.

Crossing these pistillate and staminate individuals gives normal hermaphrodites in the first generation. These plants, when self-fertilized, segregate in the following generation as expected of such a dihybrid. A majority of the resulting plants are normal hermaphrodites; a smaller number are typical silkless or male in function; and approximately an equal number are typical tassel-seed plants, female in function.

What form the double recessive, silkless-tassel-seed plants would have, with both abnormal factors in the homozygous condition, was a matter of much speculation. Such individuals might be sterile in both types of flowers and consequently neuter in function. They might be sterile in the lateral inflorescence and fertile in the terminal inflorescence. There were other possibilities but the latter result seemed to be the most probable outcome. If this proved to be the case it was thought possible to produce a dioecious corn.

In a large number of progenies segregating for both factors, grown in successive years, no plants which looked like a recombination of both genes were found. All the tassel-seed plants produced at least a vestige of a lateral ear and when these were examined they were all seen to have silks. This particular tassel-seed factor was known to be on a different chromosome from the one carrying silkless so that linkage did not prevent the recombination.

A number of second generation tassel-seed plants, carrying silkless either in one or two doses, were crossed by silkless plants heterozygous for tassel-seed. Forty-one progenies of such matings were grown and five were found to give only two types of plants—male and female. These five families were entirely dioecious, their seed parent having produced only seed and their pollen parent only pollen. In a total of 86 plants, 37 were female type and 49 male type.

From these results it was quickly apparent that the reason the doubly recessive plants, having both silkless and tassel-seed genes, were not recognized was due to the fact that they were no different in appearance from the singly recessive tassel-seed plants. Apparently tassel seed has the ability to nullify the action of the silkless gene and allows the plants to produce seed both in the tassels and in the lateral ears. On this assumption such a plant would carry silklessness in double dose and when crossed by a silkless plant that was otherwise normal would give all silkless plants. This result has practically been obtained. Out of 30 plants from such a cross, 29 were all completely silkless. There was one exceptional plant, possibly due to contamination. It would be difficult to account for it by segregation since, in that case, half of the plants should have been silkless.

There seems to be no other way to account for the five families of dioecious corn than that the mother plants with seeds in the tassel were also homozygous for silkless. Whatever the explanation, the fact is that a dioecious strain has been produced from a monoecious species. The female plants are homozygous, the male plants are heterozygous, and natural pollination of one by the other is expected to continue to give only male and female plants in approximately equal numbers. In this way an hermaphroditic organism has been changed to a separate-sexed organism.

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